SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JULY 1922.

GENERAL PHYSICS.

1455. *Reversible Pendulum.* **H. F. Dawes.** (Roy. Soc. Canada, Proc. 15. Sect. 3. pp. 125–130, 1921.)—Describes a very simple and symmetrically-formed pendulum for the determination of *g*. One part is a solid rod, the remainder a tube of the same external diameter as the rod. The two knife edges are fixed. Two adjustable masses are arranged to slide on the tube; these are equal and are always used at equal distances from the centre of symmetry of the pendulum. Hence the centre of gravity of the pendulum is never disturbed. The theory is given and the various reduction factors are dealt with. A graph is included showing how the exact length and period may be obtained from the nearest available experimental results. E. H. B.

1456. *Micromanometer sensitive to* 1/1000 *Millibar.* **F. Michaud.** (Comptes Rendus, 174. pp. 805–806, March 20, 1922.)—Describes a form of manometer for measuring very small pressures. Two vessels are united by a tube and are filled with a liquid containing a number of suspended particles too large to be affected with the Brownian movements. Into one vessel there dips a fine thread which, as it is unwound from a drum and enters the liquid, causes a very slight displacement of the level; this can be calculated from the length of thread immersed. The small pressure to be measured is applied at the second vessel and is balanced by unwinding a sufficient length of thread, the point of balance being obtained by observation of the suspended particles with a microscope. With this apparatus differences of pressure of 1/1000 millibar are measurable. J. W. T. W.

1457. *Suspended Impurities in the Air; Apparatus.* **J. S. Owens.** (Roy. Soc., Proc. 101. pp. 18–37, April 1, 1922.)—The author describes an apparatus designed by him for giving an instantaneous value of the quantity of suspended impurity in the air. A known volume of air travelling at a high velocity (probably that of sound) is pumped through a narrow slit and impinges on a microscope cover-glass. The particles which were suspended in the air adhere to the glass and the record can be examined under a microscope. The reason for the particles adhering to the glass is probably that the reduced pressure required to form the jet causes moisture to condense around the particles; as the moisture evaporates rapidly after the record is taken no confusion arises by counting water drops as dust particles. The air is saturated before being drawn into the jet by passing through a tube lined with saturated blotting-paper. The number of particles adhering is found by using a net-ruled micrometer eyepiece in the microscope; hence the number of particles per cm.^{3} of air can be calculated. The results of the determinations made with the instrument suggest that when there is no fog the visibility depends largely upon the amount of dust suspended in the air, and that this dust may have been carried over great distances by the wind. A. W. L.

1458. *Extension Measurements on Ships' Hulls; Apparatus.* **Siemann.** (Zeits. Vereines deutsch. Ing. 66. pp. 373–374, April 15, 1922.)—Describes apparatus used for the measurement of the extension of a ship's hull. Curves are given for various measurements made under practical conditions. J. W. T. W.

1459. *Bygrave's "Position Line" Slide-Rule.* (Engineer, 133. p. 250, March 3, 1922.)—The main difficulty in designing a slide-rule for reducing sextant observations lies in the great accuracy that is required. To be of any use at sea the calculation must be correct to 1 min. of arc, and this necessitates a very long scale. The rule itself is 9 in. high and 2·5 in. diameter. Two scales are printed on two cylinders sliding with reference to each other. The inner cylinder, on which all results are read, is graduated with log. tangents, and the spiral scale is about 24 ft. long. It is divided into minutes of arc throughout its length, and the smallest degree division, occurring at the middle of the scale, is over an inch in length. The outer scale is graduated with log. cosines. Two pointers, one for each scale, are attached to a sliding ring, a stop being provided to register the cosine pointer on the zero of its scale. The calculation is performed in three stages; for details of the procedure the original should be consulted. A. W.

1460. *On the Thermometric Anemometer.* **J. S. G. Thomas.** (Phil. Mag. 43. pp. 688–698, April, 1922.)—An experimental investigation of the application of the thermometric anemometer to the determination of slow rates of flow of gases is detailed. It is shown that values of such low velocities cannot, in general, be uniquely determined by such type of anemometer. This arises owing to the existence of a minimum value of the energy supply required to heat the stream through a definite range of temperature. AUTHOR.

1461. *Weighing by Substitution.* **C. A. Briggs** and **E. D. Gordon.** (Bureau of Standards, Technol. Papers, No. 208. pp. 177–192, Washington, 1922.)—A description of the processes adopted for making substitution weighings, applicable either to equal-arm balances, or compound-lever scales, developed in connection with the standardisation of large weights at the Bureau. P. E. S.

1462. *Aerial Photography for Precision Cartography.* **H. Roussilhe.** (Comptes Rendus, 174. pp. 863–866, March 27, 1922.)—Describes the use of methods which have been developed for the correction of photographs taken by aeroplane, and for determining, for any given photograph taken over known ground, the position of the aeroplane, its line of flight, and the inclination of the plate at the moment of exposure. An accuracy in the plan of 0·20 m. on a scale of 1/2000 is obtainable, heights being determined to an accuracy of 0·50 m. The method is applicable to the precision checking of registering altimeters and direction indicators, as well as to the study of stability of flight and similar problems. J. W. T. W.

1463. *Comparison of Wireless Time-Signals from Annapolis and Lafayette.* **R. M. Stewart.** (Roy. Astron. Soc. Canada, J. 16. pp. 121–124, April, 1922.)—A continuation of previous work [Abs. 428 (1922)]. Systematic observations have been made since April 1921 of the time signals received at Ottawa from the U.S. naval stations Annapolis and Arlington, and from the French stations Lafayette (Bordeaux) and Lyons. The reception of the signals was accomplished normally by the method of coincidences by extinction, which has been found to work excellently in practice, the probable error of a complete comparison under good conditions being less than 0·005 sec. The results obtained for comparison of (1) Ottawa and Washington and (2) Ottawa and Paris times, for the period April to December, are tabulated. The comparison shows the presence of comparatively large systematic effects extending over considerable periods. The differences occur frequently, in "runs" extending from a few days to several weeks or longer. The marked discordance of the individual probable errors and those deduced from monthly means points to the presence in the individual results, of systematic discordances which vary from time to time. These irregularities presumably originate in the observed values of clock correction at the three observatories concerned. The cause of such errors is obscure and needs elucidating. A. W.

1464. *General Method for Determining Properties of Matter.* **M. D. Hersey.** (Washington Acad. Sci., J. 12. pp. 167–172, April 4, 1922.)—Restrictions arising in existing methods are briefly referred to and a further category of experiments, less restricted in character, is indicated. It consists in a reversed application of the principle of dynamical similarity (or physical similarity). In general, the appropriate dimensionless equation for some chosen phenomenon exhibiting the desired property Q is developed. Then, either by Buckingham's method of suppressed dimensions, or by arrangement of experimental facilities, the equation is reduced to the form $Q = x\phi(y)$. Observations of the phenomenon are taken on a standard sample, giving values x_0 and y_0 corresponding to Q_0 and repeated on the sample for which Q is unknown. Values of y/y_0 are plotted against values of x/x_0. The abscissa of P where the experimental curve crosses the line $y/y_0 = 1$ is denoted by x_1/x_0. P represents a fictitious case of dynamical (or physical) similarity, obtained by interpolation between adjacent points at which the conditions for similarity are not exactly fulfilled. All the inferences appropriate to physically similar systems are immediately applicable to the coordinates of P. When $y/y_0 = 1$, the reduced equation first developed gives the formula $Q/Q_0 = x_1/x_0$ for determining Q. This formula is theoretically exact under the conditions stated, regardless of the complexity of the fluid motions, heat transfer, or electrical distributions involved in any given experiment. The method is applied, by way of example, to viscosity measurement and to determination of thermal conductivity. A. B. C. L.

1465. *The Gravitation Needle in High Vacua.* **C. Barus.** (Nat. Acad. Sci., Proc. 8. pp. 63–66, April, 1922.)—The periods and logarithmic decrement are given of the torsion system in the apparatus previously described by the author [see Abs. 5 (1921)]. L. H. W.

1466. *A New Form of High Vacuum Automatic Mercury Pump.* **H. P. Waran.** (Phys. Soc., Proc. 34. pp. 120–124; Disc., 124–125, April, 1922.)

1467. *A Defect in the Sprengel Pump: Its Causes and a Remedy.* **J. J. Manley.** (Phys. Soc., Proc. 34. pp. 86–90; Disc., 90–91, April, 1922.)

1468. *Numerical Solution of Partial Differential Equations arising in Technical Problems.* **H. Hencky.** (Zeits. Math. u. Mechanik, 2. pp. 58–66, Feb., 1922.)—The differential equations are replaced by equations of finite differences, and the solutions of these are shown to be sufficiently accurate for most practical purposes. Examples on elastic plates, and on the flow past an obstacle are worked out in detail. W. G. B.

1469. *Bending of Continuous Plates, and the Rectangular Plate with Free Edges.* **A. Nádai.** (Zeits. Math. u. Mechanik, 2. p. 1–26, Feb., 1922.)—Solutions of the equations of deformation of an elastic plate, when the forces act at the nodes of a lattice pattern, are given. Particular attention is given to the square plate with free edges, acted upon by a symmetrically distributed set of normal forces, with and without a uniform normal pressure. Numerical results and diagrams of the lines of equal deflection are given for a few cases:—Square plate supported at the corners acted upon by two equal forces at the middle points of two opposite sides; square plate subjected to a uniform normal pressure, and supported (*a*) at the corners, (*b*) at the middle points of the sides, (*c*) at eight points. W. G. B.

1470. *General Theory of Plate Springs.* **Y. Tanaka.** (Zeits. Math. u. Mechanik, 2. pp. 26–34, Feb., 1922.)—General equations for the deformation of built-up plate springs are given and solved. The solutions are applied to numerical examples, and the results compared with experiment. W. G. B.

1471. *Transverse Vibrations of Rods.* **W. Kaufmann.** (Zeits. Math. u. Mechanik, 2. pp. 34–45, Feb., 1922.)—The lateral vibrations of a rod due to an impact are worked out for the fixed-free and doubly supported cases. Period equations are obtained, and solved to four figures, for a rod with three and four supports. W. G. B.

1472. *Circular Plates of Variable Thickness.* **G. D. Birkhoff.** (Phil. Mag., 43. pp. 953–962, May, 1922.)—A method of dealing with deformations and stresses in circular elastic plates of variable section, based upon the fact that the strain energy is a minimum, is illustrated by being applied to two cases. The first is that of an incomplete plate, clamped at the edge, and subjected to a uniform radial force at the inner edge. The second is that of a plate clamped at the edge and subjected to a uniform normal pressure. W. G. B.

1473. *Forced Vibrations of Bridges.* **S. Timoshenko.** (Phil. Mag. 42. pp. 1018–1019, May, 1922.)—The forced vibration of a uniform beam, with supported ends, due to a travelling periodic force is calculated. It is shown that the deflection may be large if the period of the force coincides with one of the natural free periods of the beam. The results give some idea of the "impact" effect of an imperfectly balanced locomotive on a bridge. W. G. B.

1474. *Validity of Hertz's Formulæ for the Flattening of Bodies under Pressure.* **G. Berndt.** (Zeits. techn. Physik, 3. 1. pp. 14–21, and 3. 3. pp. 82–87, 1922.)—The conclusion reached after considering numerous experimental results, as well as the basic assumptions of the theory, is that the formulæ hold for isotropic elastic bodies, so long as they obey Hooke's law, showing no residual strain, provided friction between the surfaces is negligible. For the case of a steel sphere on a steel plate, the limiting condition is $P < 0 \cdot 25\, r^2$, where P is the total pressure in kg., and r the radius in mm. W. G. B.

1475. *Strengthening of Single Crystals by Mechanical Stress.* **M. Polanyi.** (Zeits. Elektrochem. 28. pp. 16–20, Jan. 1, 1922. Paper read before the Deut. Bunsen Gesell., Jena, Sept., 1921.)—The tensile strength of hard-drawn tungsten wire of fibrous structure ranges from 330 to 420 kg./mm.^{2}, that of Pintsch's single-crystal wires is 108 kg./mm.^{2}. In the former case the wire axis and stress direction are parallel to the diagonal of the cubic face, which, in the latter case, may have any orientation (Gross and Blassmann). The author explains the strength relations with the aid of crystal models. Single crystals are generally weaker than hard-drawn wires, but they can be made stronger by cold work. This has been shown for tungsten by Schönborn [see Abs. 1404 (1922)], and by E. v. Gomperz, who raised the strength by 38 % by repeatedly breaking the specimen in tensile tests and by hard-drawing the wires (strength increase of 42 % by drawing the dark-red wire 6 times through diamond dies); and also by I. Peters for rock salt. The prism of rock salt is ground along the prismatic axis; the surface layer, 1 mm. in depth, is made stronger, but weakened again by heating to 400°. H. B.

1476. *Young's Modulus and Poisson's Ratio for Spruce.* **H. Carrington.** (Phil. Mag. 43. pp. 871–878, May, 1922.)

1477. *Free Transverse Vibrations of a Uniform Circular Disc Clamped at its Centre; Effects of Rotation.* **R. V. Southwell.** (Roy. Soc., Proc. 101. pp. 133–153, May 1, 1922.)—Mathematical; an extension of Kirchhoff's analysis suggested by failures in turbine discs. L. H. W.

1478. *Boundary Lubrication: The Paraffin Series.* **W. B. Hardy** and **[Miss] I. Doubleday.** (Roy. Soc., Proc. 100. pp. 550–574, March 1, 1922.)—In what is called complete lubrication the solid surfaces are completely floated apart by the lubricant. There is, however, another kind of lubrication in which the solid faces are near enough together to influence directly the physical properties of the lubricant, a condition found with dry or greasy surfaces. What Reynolds terms "boundary conditions" then operate, and the friction depends not only on the lubricant but also on the chemical nature of the solid boundaries. Boundary lubrication differs so greatly from complete lubrication as to suggest that a discontinuity exists between the two states. In the former the surfaces have the property of static friction, and the resistance is some inverse function of the viscosity of the lubricant. In complete lubrication static friction is absent, and the resistance varies directly with the viscosity of the lubricant. The present paper deals only with boundary lubrication, and the inquiry is limited to the lubricating qualities of normal paraffins and their related acids and alcohols. The molecules of the substances employed, therefore, consist either of a single chain of carbon atoms to which are attached atoms of hydrogen, or of such a chain loaded at one end with the hydroxy group, —OH, or the carboxyl group —COOH. Attention has been concentrated chiefly on 3 variables—the quantity of lubricant present, the composition of the solid faces, and the chemical constitution of the lubricant. The relations disclosed by the experiments are of surprising simplicity, whilst their interpretation is difficult. The paper has accordingly been divided into two parts, the first devoted to the results of experiment and the second to theory. The tables given include values of the coefficient of friction for polished surfaces of bismuth, which are taken from an earlier paper, but the author observes that a much higher order of accuracy was arrived at in the measurements with glass and steel than in those made previously with bismuth. The influence of the quantity of lubricant was studied and three methods of lubricating the surfaces were adopted. The data shows the friction to be independent of the quantity of lubricant present, provided there is enough to cover the surfaces with the invisible primary film. The critical value of friction, i.e. independent of the quantity of lubricant present, is that of faces so lubricated as to be in equilibrium with saturated vapour. The results obtained by using the lubricant as vapour confirm this view, while the critical friction is also the lowest value which can be obtained in boundary friction. The fall in friction is proportional to the concentration of chemical molecules of the lubricant in the gas phase; i.e. each such molecule exerts the same influence as every other, and that due to each molecule is a pure function of its field of force, that is, of its atomic configuration. Solid lubricants were investigated, although it is more difficult to follow the influence of the quantity of lubricant when it is a solid, because neither primary spreading nor the vapour phase can be utilised. Finally the influence of chemical constitution was examined, and for each chemical series the curve, when the coefficient of static friction was plotted against the molecular weight, was found to be a straight line. The effect of the nature of the solid face was unexpectedly simple. In changing from glass to steel the curve for a series is merely moved parallel to itself, and in moving from steel to bismuth there is a further shifting.

In the theoretical section of the paper, Coulomb's hypothesis that friction is due to the interlocking of asperities is discussed, as also the view taken in earlier papers that friction is due to molecular attraction operating across an interface. Appendix I deals adversely with Chaumat's claims that friction depends not only on the pressure but on the degree of asymmetry of the loading. H. H. Ho

1479. *On the Theory of Lubrication.* **L. Gümbel.** (Zeits. techn. Physik, 3. 3. pp. 94–101, 1922.)—The author deals with points of difference between his and Sommerfeld's theories. Sommerfeld's theory implies the existence of negative pressures in the oil, but this is not probable. Recent experiments by O. Lasche support the author's view that the pressure falls to zero just behind the point where the oil film is thinnest, and that it never becomes negative, but thence remains zero. Measurements of the displacement of the centre of the shaft, by Vieweg, for various speeds, agree with the author's calculations, that with increasing speed this decreases, and its direction turns through a right angle in the direction of rotation. With regard to Sommerfeld's explanation of the minimum frictional torque, measurements of the electrical resistance of the oil film have shown a sudden increase on passing this minimum, which points to the fact that for lower speeds there is sliding friction. It is also pointed out that Sommerfeld's calculation of this minimum is bound up with the existence of negative pressure. W. G. B.

1480. *Surfaces of Discontinuity.* **G. Camichel.** (Comptes Rendus, 174. pp. 666–669, March 6, 1922.)—Gives further details concerning surfaces of discontinuity actually produced and observed in the flow of water [see Abs. 720 (1922)]. For the case of flow past a plate 3 cm. wide in a channel 15 cm. by 3 cm., the surface of discontinuity is quite clear for one cm. or so, but then becomes confused owing to the formation of vortices. Its form agrees closely with that calculated. Allowing air to enter behind the obstacle, it remains there, and the flow with a free surface is obtained. The vortex with a rotating core surrounded by liquid moving irrotationally was realised, and the theoretical relation between velocity and radius was verified. These results show that for the greater part of a moving liquid, a velocity potential exists, and emphasise the practical importance of functions of a complex variable. W. G. B.

1481. *Impulse Waves and Detonation; Possible Attainment of very High Pressures.* **R. Becker.** (Zeits. f. Physik, 8. 5. pp. 321–362, 1922.)—A mathematical paper in which various complicated possibilities are dealt with. The actual breadth of the wave-front for a gas and for a liquid is quantitatively calculated. By introduction of a chemical combination inside the wave-front it is possible to obtain a complete grasp of the phenomena of detonation and combustion. It appears possible, by help of detonation phenomena, physical properties and chemical reactions, to reach pressures of the order of a *hundred thousand atmospheres.* E. H. B.

1482. *Effect of Variable Specific Heat on the Discharge of Gases through Orifices or Nozzles.* **W. J. Walker.** (Phil. Mag. 43. pp. 589–593, March, 1922.)—In the flow of gases through nozzles and orifices, constancy of the specific heat of the gas concerned is usually assumed. The formulæ derived under this assumption are set forth. In applying these equations to experimental results it is customary to account for departures from theoretical discharges by a suitable variation of γ. This is not satisfactory, and the author deduces a rational formula, assuming variable specific heat conditions. Since the actual adiabatic equation under *linear* variable specific heat conditions is $pv^m e^{\lambda T}$ = constant, the latter equation has been taken as the basis for the purpose of determining as nearly as possible what effect such specific heat variation has on discharges. It is deduced that the velocity as given in the usual equation has to be multiplied by a factor, $1 + \lambda T_1(1 - s^{(m-1)/m})/4m$, and the quantity discharged by the factor $1 + 3\lambda T_1(1 - x^{(m-1)/m})/4m$, to a first approximation. It is pointed out that the error in computing discharges, by the usual constant-specific-heat theory, increases as the density of the gas in the reservoir is diminished. The method of orifice discharge might be employed as a reliable and convenient one for the determination of specific heat variations with temperature. The conclusions reached are somewhat similar to those arrived at in a previous paper on thermodynamic cycle efficiencies [Abs. 1153 (1917)]. T. B.

1483. *Lagrange's Ballistic Problem.* **A. E. H. Love** and **F. B. Pidduck.** (Roy. Soc., Phil. Trans. 222. pp. 167–226, March 6, 1922.)—The problem considered is that of a given mass of gas contained in a segment of a uniform tube between two pistons, at a high initial pressure. In consequence of this pressure the pistons begin to move outwards, and it is required to determine their motion and the state of the gas at any time. Wave motion of finite amplitude is set up in the gas, and as a preliminary the theory of this is collected. An approximate method of determining the waves reflected from the moving pistons is found. The analysis is carried as far as the second reflected wave, since this seems to be sufficient for practical applications. The results are applied to a numerical example, and curves showing pressures, velocities, and displacements at any time are given. W. G. B.

1484. *Curvature of Space.* **J. Le Roux.** (Comptes Rendus, 174. pp. 924–927, April 3, 1922.)—It is claimed that the notion of the curvature of space, with which is associated the question of the finite or infinite nature of the universe, involved in Einstein's generalisation of the theory of relativity, is based upon an inexact analysis not according with facts. A mathematical argument is developed from which it is concluded that space cannot be described as Euclidian or non-Euclidian, these features being ascribable only to the systems of measurement employed. Space can be regarded as finite or infinite according to the system of measurement chosen. A. B. C. L.

1485. *Space in Reference to the Theory of Relativity.* **E. Cartan.** (Comptes Redus, 174. pp. 734–737, March 13, 1922.)—A general comparison, based on the treatment developed in a previous paper [see Abs. 1059 (1922)] of the elemental characteristics of the Euclidian universe, and the universe according to Einstein and H. Weyl. A. B. C. L.

1486. *Proposed Laboratory Test of the Theory of Relativity.* **H. S. King.** (Nature, 109. pp. 582–583, May 6, 1922.)—From the equation, derived from the theory of relativity, expressing the arithmetical relationship between matter and energy, a calculation is made of the atomic weight of radium. The assumptions involved and their effects on the accuracy of the result obtained are briefly discussed, and to obtain a more exact test of the calculation the possible employment of a refined method of positive-ray analysis is indicated.

R. W. Lawson. (*Ibid.*, p. 613, May 13, 1922.) A. B. C. L.

1487. *Effect of Lunar Gravity on a Torsion Balance.* **R. C. Hartsough.** (Phys. Rev. 19. pp. 282–283, March, 1922.)—The balance is constructed on the lines of the Threlfall's " Gravity Balance," but it has a long vertical arm and suspended mirror for increased sensitiveness. Also the apparatus was enclosed in a vessel which was exhausted to 0·03 mm. of mercury pressure. Experiments showed that the moon disturbs the balance over 24-hour periods. There is a max. decrease in the earth's field at upper culmination, and a minimum at lower culmination, of the moon. P. E. S.

1488. *Possibility of Testing the Special Relativity Principle Astronomically.* **A. Kopff.** (Phys. Zeits. 23. pp. 120–121, March 1, 1922.)—It is shown that classical astronomical methods and the special relativity theory lead to similar expressions for the yearly aberration of the stars. Calculation then shows that it may just be possible, by observations on a suitable spiral nebula with great radial velocity, to measure the yearly aberration of the nebula with respect to neighbouring fixed stars. Observations on a great number of stars may, by use of a formula given, enable the sun's motion relative to the star system to be determined. A. W.

1489. *Relations in Einstein's Theory.* **G. B. Jeffery.** (Phil. Mag. 43. pp. 600–603, March, 1922.)—Mathematical.

1490. *A Definition of Simultaneity and the Ether.* **E. H. Synge.** (Phil. Mag. 43. pp. 528–531, March, 1922.)

1491. *Surface Tension of Soap Solutions for Different Concentrations.* **A. L. Narayan** and **G. Subrahmanyam.** (Phil. Mag. 43. pp. 663–671, April, 1922.)

1492. *Thermodynamical Theory of Surface Tension.* **S. Sano.** (Phil. Mag. 43. pp. 649–658, April, 1922.)

1493. *Magnetic Model of Atomic Constitution.* **J. K. Marsh** and **A. W. Stewart.** (Nature, 109. p. 340, March 16, 1922.)—A close approximation to the neutral atom is achieved by using a series of equal vertical magnets all with their north poles upwards. Using a lead tank with water, each floating magnet is accompanied by two others, one fixed below water and another above water. When the number of floating magnets corresponds to the units of atomic weight in an element, the magnets arrange themselves into two distinct groups, a central group or nucleus and an outer group or ring. In this way, atomic models have been formed of the elements from hydrogen to neon (20 magnets), and the groupings agree with Aston's suggestions, elements and isotopes having their parallels in the models. The number of magnets in the ring is always equal to the max. valency of the element plus two units, and it is suggested that the eight elements up to fluorine are built with two residual non-detachable electrons in the ring. For the atomic weights 2, 3, 5, and 8, which have no corresponding elements, the magnetic model supplies forms corresponding to isotopes of H, He, Li, and Be or Li respectively. G. E. A.

1494. *Effective Cross-Section of Gas Molecules towards Slow Electrons.* **C. Ramsauer.** (Ann. d. Physik, 66. 8. pp. 546–558, March 22, 1922.)—This paper forms a continuation of a previous one [Abs. 996 (1921)], and describes experiments on helium, neon, and argon. Experiments with krypton and xenon will be described later. It was found that on passing from higher values of the electron velocity (*e.g.* 50 volts) to smaller values, the effective cross-section at first increases, reaches a maximum, and finally decreases. This effect was found with helium, neon, and argon, but the effect is much more marked in the case of argon than with the other two gases. Argon shows a very high maximum, with values approximating to zero on either side. This means that an electron of the smallest velocity can pass freely the argon atom, without being absorbed or reflected. Comparison with the absorption cross-section given by Mayer for argon and helium [Abs. 906 (1921)] shows that for the smallest electron velocities the effective cross-section and the absorption cross-section are the same, but that this is certainly not the case for higher electron velocities. A. W.

1495. *Bohr's Atomic Model. Circumnuclear Function of Lagrange.* **M. Brillouin.** (J. de Physique et le Radium, 3. pp. 65–73, March, 1922.)—The author considers Bohr's atomic model to be essentially one for the spectroscopist. It does not appear as yet to account for the circumnuclear region, the laws for which are still unknown. A. W.

1496. *Pyro-Electricity, Temperature, and the Lattice Theory.* **M. Born.** (Phys. Zeits. 23. pp. 125–128, March 1, 1922.)—According to Grüneisen the thermal expansion should vary as the energy, and hence at low temperatures (Debye) with the fourth power of the absolute temperature. Considerations of the lattice theory speak for a proportionality to T^2, not T^4, and this applies also to pyro-electricity, which W. Ackermann (Dissert., Göttingen, 1915) investigated down to the temperature of liquid hydrogen. The author now finds that this T^2 rule had already been recognised by Boguslawski [Abs. 1601 and 1886 (1914)]. Ackermann's data are not sufficient, however, and further determinations of the pyroelectric moment and of thermal expansion at very low temperatures are required. H. B.

1497. *The Sizes of Atoms in Crystals.* **R. N. Pease.** (Am. Chem. Soc., J. 44. pp. 769–774, April, 1922.)—As an alternative to W. L. Bragg's view that the distances between atoms in crystals can be expressed in terms of atomic radii characteristic only of the element concerned, it is suggested that the particular element is of secondary importance, *for elements whose atoms are of the same rare-gas type*, and that the contribution of an atom to the distance between it and another atom in a crystal depends upon the number and arrangement of electrons about its positive nucleus, upon the type of lattice, at least as this affects the latter, and, ordinarily, upon the magnitude of the charge carried by the atom. The inter-atomic distances in substances crystallising in the diamond type of lattice have been analysed from this point of view. AUTHOR.

1498. *Crystal Structure of Ice.* **W. H. Bragg.** (Phys. Soc., Proc. 34. pp. 98–102; Disc., 102–103, April, 1922.)—The methods of X-ray analysis have been applied to ice by St. John and by Dennison. The former refers the structure to a lattice composed of right triangular prisms of side 4·74 Å.U. and height 6·65 Å.U.; the latter to a similar lattice of dimensions 4·52 and 7·32 respectively. The actual arrangement of the atoms is not found in either case. On certain suppositions, the arrangement can be found independently of direct X-ray analysis in the following way. Let it be assumed that each positive ion is surrounded symmetrically by negative ions, and *vice versa*; and in view of the low density of ice, let the number of neighbours be in each case as small as possible. The crystal is to be hexagonal, and is to have the right density. The result is that each oxygen atom is at the centre of gravity of four neighbouring oxygens, from each of which it is separated by a hydrogen atom. The dimensions of the structure agree with Dennison's figures.

The conclusion is supported by a comparison between the calculated intensities of reflection and the observed intensities as recorded by Dennison. AUTHOR.

1499. *Crystal Structures of the Cuprous Halides.* **R. W. G. Wyckoff and E. Posnjak.** (Am. Chem. Soc., J. 44. pp. 30–36, Jan., 1922.)—This determination of crystal structure, as described in the present paper, outlines the manner of application of the general method of study based upon the results of the theory of space groups to cubic compounds of the type RX (where R and X are atoms of the same valence) when all of the diffraction data are furnished by a study of the powder photograph from the crystal under investigation [see Abs. 1206 (1921)]. Because no crystals of this type have as yet been found for which it is necessary to assign a structure containing more than four molecules within the unit cell in order to arrive at a qualitative agreement with the experimental results, discussion is limited to possible structures having not more than 4 molecules in the unit. The crystalline materials employed, namely, the various cuprous halides, are described, and the powder spectrographs discussed. Because of discrepancies in the recorded values, redeterminations of the densities of cuprous chloride and cuprous iodide were made by a pyknometer method, and found to be at 30° against water at 4°, 4·136 and 5·667 respectively. The possible arrangements of the atoms in the unit cells are next discussed, for the cases of 1, 2, 3 and 4 chemical molecules within the unit. The choice of the correct structures is then investigated, tables of arrangements are included, and their chemical significance discussed. It has previously been pointed out that with compounds of a certain type (the valence compounds, in which the chemical bends are electrons shared by two atoms) there might be such a connection between the positions of the atoms and their chemical valence as would enable the prediction of the manner of combination of the atoms of a compound from the arrangement of its atoms.

As a consequence of this study of the cuprous halides, then, it will be necessary to abandon these simple considerations, and, when attempting to correlate crystal structure and the nature of chemical combination, to view such factors as the shapes and sizes of atoms as important in determining the arrangement of the atoms in crystals. Cuprous chloride, bromide, and iodide all have the "zinc sulphide arrangement" of their atoms in crystals. The lengths of the sides of the unit cubes in the three cases are 5·49, 5·82, and 6·10 Å.U. respectively. H. H. Ho.

1500. *Crystal Structure of Silver Oxide* (Ag_2O). **R. W. G. Wyckoff.** (Am. J. Sci. 3. pp. 184–188, March, 1922.)—Employing the method of powders, it is shown that silver oxide has the same structure as that assigned to cuprous oxide. The length of the side of the unit cube is determined to $4 \cdot 76_8$ Å.U. AUTHOR.

1501. *Crystal Analysis by Powder Method ; Effect of Form and Dimensions of Sample.* **L. W. McKeehan.** (Frank. Inst., J. 193. pp. 231–242, Feb., 1922.)—An X-ray crystal analysis of certain alloys by the powder method has shown that errors due to the finite dimensions of the samples employed become appreciable when max. accuracy is attempted. A description is now given of an investigation of the magnitude of such errors. Both theory and experiment now indicate that, for great accuracy, a thin plate of crystalline powder is preferable to a circular cylinder. This is the more important the greater the opacity of the powder to the X-rays. If a cylindrical form is unavoidable, the smallest diameter which gives a measurable photograph will be found to be the best. If the sample is very opaque, it is advantageous to dilute it with amorphous material of negligible absorption coefficient, the dimensions of the sample being unchanged. A. B. W.

1502. *Crystal Structure of the Common Elements.* **A. W. Hull.** (Frank. Inst., J. 193. pp. 189–216, Feb., 1922.)—The paper gives a brief history of the subject up to date, concluding with a very useful list of 41 references. Valuable information is included in the paper in tabulated form, thus: (1) Crystal structure of the elements from lithium to thorium. Type of lattice; axial ratio; lattice constants; closest approach of atoms; authority. (2) Radii of atoms—as determined by measurements of viscosity (Rankine), compressibility (Richards), atomic structure (Landé), X-ray data (Bragg and Davey). (3) Crystal structure of compounds. Details of structure of 54 chemical compounds. A. B. W.

1503. *Crystal Structure of Potassium Cyanide.* **R. M. Bozorth.** (Am. Chem. Soc., J. 44. pp. 317–323, Feb., 1922.)—The crystal structure of KCN has been determined by means of X-rays, using the Laue transmission method, the Bragg spectrometer method, and Debye's powder method. All the data point to the conclusion that the structure of KCN approximates to that of NaCl. Consequently, the potassium atoms were placed at the sodium atom positions and the carbon and nitrogen atoms near the chlorine atom positions. The positions of carbon and nitrogen atoms which give the best agreement with the experimental data place these atoms $1 \cdot 15 \times 10^{-8}$ cm. apart, equidistant from the position of the chlorine atom of NaCl. Representations of the crystal model of KCN are given in the paper. A. B. W.

1504. *Cohesion.* **W. Taylor.** (Nature, 109. pp. 10–11, Jan. 5, 1922.)—This is a preliminary description and discussion of experiments tending to confirm the author's hypothesis of the nature of cohesion [Abs. 1972 (1921)]. Mercury spheres of diameters ranging from 0·05 mm. to 1·5 mm. were held in suspension by surface tension from a drop of water wetting a glass surface above, and spheres of diameters ranging from 0·05 mm. to 2·25 mm. were similarly suspended from a glass surface. Microscopic measurements were then made of the diameters and of the contact areas and angles, from which the ratios W/T were calculated, W being the weight of a mercury sphere and T the vertical component of the surface tension, T in the second series being taken as that of mercury. The result was a decrease of T/W, with increasing diameter, from over 6000 to about 2, in the second series. In the first series the decrease over the same range would be about 3000 to 1. Had, however, T been calculated from $\sigma = 270$ instead of 547, in the second series the decrease would have been from about 3000 to 1 as in the first series, from which the author concludes that 270 may be considered as an approximation to the surface tension of glass. The increasing values of T/W for the smaller particles would account for the persistence with which molecules of a gas condense on a glass surface. He also noted that small particles of an insoluble solid remained attached to glass or other solids on the evaporation of the connecting drop, and the known fact that minute solid particles coming into contact with a solid body remain attached, even when both are clean and dry.

All these facts appear further to confirm the author's previous conclusions. Assuming the essential identity between surface tension, cohesion and adhesion, and extending to molecules, the force binding two molecules of water together will be $2{\cdot}05 \times 10^{-5}$ dyne; and in the case of mercury, $7{\cdot}7 \times 10^{-5}$ dyne, which agrees with Chatley's conclusion from experiments on river mud [Abs. 1527 (1921)]. G. W. DE T.

1505. *Crystal Structure of Sodium Chlorate and Sodium Bromate.* **N. H. Kolkmeijer, J. M. Bijvoet,** and **A. Karssen.** (K. Akad. Amsterdam, Proc. 23. 4. pp. 644–653, 1921.)—Using the apparatus described in a previous paper, the authors have determined, by the X-ray powder method, the crystal structure of sodium chlorate and bromate. For details of the results it will be necessary to refer to the original paper. A. B. W.

1506. *Crystal Structures of Complex Cyanides of Potassium with Zinc, Cadmium, and Mercury.* **R. G. Dickinson.** (Am. Chem. Soc., J. 44. pp. 774–784, April, 1922.)—By means of spectral photographs and unsymmetrical Laue photographs, the structures of $K_2Zn(CN)_4$, $K_2Cd(CN)_4$, and $K_2Hg(CN)_4$ have been determined. A remarkable fact is that these complex cyanides have the same structure as magnetite (Fe_3O_4) and spinel ($MgAl_2O_4$). L. H. W.

1507. *Possible Rainfall Period equal to One-ninth the Sun-Spot Period.* **D. Alter.** (Kansas Univ., Sci. Bull. 13. No. 8. pp. 101–105, May, 1920.)—This is in continuation of a previous paper (Monthly Weather Rev., Feb., 1921.)—The author regards the sun-spot period as varying continuously about the average length 11·13 years, according to a curve which he has constructed from the sun-spot numbers. He then holds that statistical analysis described in these papers provides strong evidence of the existence in the United States rainfall of a period equal to one-ninth the sun-spot period and varying so as to keep in step with the sun-spot cycle. M. A. G.

1508. *Application of Marvin's Periodocrite to Rainfall Periodicity.* **D. Alter.** (Kansas Univ., Sci. Bull. 13. No. 9. pp. 109–114, May, 1920.)—Marvin's periodocrite is a statistical criterion for the discrimination between real and chance periodicities [see Abs. 1034 (1922)]. The author here employs it as a test of the reality of his suspected period in United States rainfall equal to one-ninth the principal sun-spot period [see preceding Abs.], with a result favouring the existence of such a period. A slight modification in the method of application of the periodocrite is also suggested. M. A. G.

1509. *Spectrophotometric Measurements of the Brightness of the Sky during the Solar Eclipse, April 8, 1921.* **R. Dietzius.** (Meteorolog. Zeits. 38. pp. 292–296, Oct., 1921.)—Measurements were made in Vienna of the relative brightness in certain narrow spectral regions, at points at intervals of 10° along the solar vertical from horizon to horizon, both during the eclipse and, for comparative purposes, on a subsequent day. The results, which are given in the paper, are regarded as preliminary and are not made the basis of any important conclusions, but the experiments are thought valuable as showing that the instrument employed (double-slit spectrophotometer of Vierdort) can be suitably adapted for such observations. Light from a selected region of the sky is reflected through one slit and that from a comparison lamp through the other, so that the spectra are seen one above the other. The width of the appropriate slit is adjusted until the portion of the spectrum under observation appears equally bright in the light from both sources, when the width of the slit serves as a measure of the brightness of the sky light for that wave-length. M. A. G.

1510. *Frequencies of Haloes and Cirro-Stratus Cloud in Tokyo.* **T. Rokuzyô and C. S. Chow.** (Phys. Math. Soc. Japan, Proc. 4. pp. 47–49, March, 1922.)—Isopleths are given for monthly frequencies of haloes in Tokyo for the years 1900–13 (smoothed), frequency of cirro-stratus cloud in Tokyo, and for the monthly values of sun-spot numbers. The resemblance observed between the latter two suggests an intimate relation between the formation of upper cloud and the solar activities. A. W. L.

1511. *Semidiurnal Wind-Wave in the Free Atmosphere above Java.* **W. van Bemmelen and J. Boerema.** (Meteorolog. Zeits. 38. pp. 328–331, Nov., 1921.)—Pilot-balloon observations at Java, mostly by two-theodolite method, are used to demonstrate the existence near the equator of a semidiurnal wave in wind in the free atmosphere at least up to 6 km. and probably to 11 or 12 km. The results accord with theory [see Abs. 508 (1910)] in that the amplitude of the north-south component is very small. The observed amplitude of the east-west component is, however, greater than the theoretical value. Further, in agreement with theory, the phase of the latter component at 4 km. differs little from that of the semidiurnal pressure-wave at that height and there is a suggestion of a corresponding retardation with increasing height, up to 6 km. Above this the phase angle of the wind-wave appears to increase with height, but the reality of this is uncertain and it may be reversed when further observations are available. M. A. G.

1512. *Is the Atmosphere Warmed by Convection from the Earth's Surface?* **W. Schmidt.** (Meteorolog. Zeits. 38. pp. 262–268, Sept., 1921.)—By convection is here understood the combined effect of pure thermal convection caused by warming of the lowest layers by contact with a heated surface and also mixing of dynamical origin arising out of the passage of air over the earth's rough surface. Evidence is produced to show that when the latter is present mixing is in general much more effective and the flux of heat greater than when the former alone is active. The direction of the flux of heat depends on whether the actual temperature gradient exceeds or falls short of the adiabatic, and by consideration of the average observed lapse of temperature in different regions, and including in the higher layers latent heat carried up by water-vapour and liberated when condensation occurs, the author draws the conclusion that, contrary to the usual view, except for a comparatively narrow equatorial zone, the average flux of heat by convection over most of the globe is *towards* the earth's surface, which in this respect exercises a cooling action. But the lower atmosphere may be warmed on the average by long-wave radiation emitted by the earth. M. A. G.

1513. *Cyclone which Crossed the Corean Peninsula and the Variations of its Polar Front.* **T. Kobayasi.** (Roy. Meteorolog. Soc., J. 48. pp. 169–183; Disc., 183–184, April, 1922.)—The life history of a cyclone which crossed the Corean Peninsula is traced by constructing synoptic charts of the distribution of pressure, temperature, and wind at intervals of four hours, together with charts showing the estimated simultaneous distribution of pressure at the 3-km. level, based on an assumed lapse of temperature of 6° C. per 1000 m. Examination of the complete set of charts leads to the conclusion that the depression crossed the mountain range by first inducing a secondary along the "steering line" *at the surface* on the further side, which then extended *upwards* until it joined the primary at a higher level, after which it developed while the original centre disappeared. The example also brings out the existence of lines of discontinuity of temperature, etc., associated with cyclones of the Far East as dealt with for Norwegian regions by Bjerknes, but a departure from Bjerknes' scheme is noted in that the wind along the cold side of the "squall line" is directed *outwards* from the centre. It is further emphasised that "cold" and "warm" sectors are purely relative terms, and that there may exist in a cyclone several air masses, each of uniform temperature intermediate between true polar and true equatorial air. The example provides an illustration of several places in which secondaries may form—under certain circumstances in the "steering" or "squall" line, or in the cold current in rear of a depression—also when a strong wind is obstructed by a mountain range a secondary may be induced on the further side, but this soon dies out unless connected with a "polar front." The whole behaviour of the cyclone as shown by these diagrams is of importance in connection with a theory of the mechanism of extra-tropical cyclones, involving the idea of the interaction of horizontal and vertical vortices, to be published by S. Fujiwhara. M. A. G.

1514. *Land and Sea Breezes in the Gulf of Lyons.* **M. Moye.** (Meteorolog. Mag., March, 1922. Nature, 109. pp. 489–490, April 15, 1922.—Abstract.)—This article contains the summarised results of a detailed study of land and sea breezes based on the author's observations at Montpellier on the south coast of France, and of a complete investigation by E. Fontséré of such phenomena on the Catalonian coast at Barcelona. Sea breezes are both preceded and followed by a period of calm, the latter of the longer duration, separating them from the land breezes of the night hours. The land breezes are much lighter and blow intermittently, but there is a definite increase in force at sunrise just before the calm preceding the advent of the sea breezes. In midsummer, at Barcelona, the sea breeze sets in about 8 a.m. simultaneously all along the coast, and then spreads both seawards and landwards. The effect invades the land area at a rate of about 7 miles/hour, reaching its farthest point 25 to 30 miles inland about midday. The max. force occurs later, 2 p.m. on the coast and 5 p.m. inland. At 6 p.m. there is a sudden termination over the whole area. The vertical extent of the sea breeze is also considered, on the basis of pilot-balloon observations. The thickness is at first only 300 to 400 ft., gradually increasing to 3000 or 4000 ft. in the afternoon at Barcelona (2000 ft. at Toulon). Above this is a calm layer about 700 ft. thick with a return current above which may extend to 10,000 ft. Details are given of the seasonal variation of frequency and the diurnal variation of direction and force. It is also indicated that while the sea breeze exerts a modifying influence on the temperature it is not responsible, in the regions considered, for the great changes accompanying it in tropical regions. M. A. G.

1515. *The Drought of* 1921. **C. E. P. Brooks** and **J. Glasspoole.** (Roy. Meteorolog. Soc., J. 48. pp. 139–166; Disc., 166–168, April, 1922.)

1516. *Latitude Variation.* **F. Schlesinger.** (Astron. J. 34. pp. 42–44, March 22, 1922.)—Lambert [Abs. 1253 (1922)] recently calculated the changes in latitude of all the international stations using Auwers' systematic corrections and weights. The present paper investigates the results due to an application of Boss's system. It is found that the present data can then be interpreted without assuming that the latitude of any station, except Mizusawa, is changing to any serious extent. It is not possible to say whether the latitude of Mizusawa is changing or whether the pole is moving. If Auwers' system is accepted it implies that six of the latitude stations are moving north, but Boss's proper motions greatly reduce these apparent motions and make their sum practically zero. W. A. R.

1517. *Periodic Phenomena in the Baltic Sea.* **O. Meissner.** (Phys. Zeits. 23. pp. 121–123, March 1, 1922.)—Observations made at a number of stations on the Baltic coast by means of self-recording level gauges, have shown that periodic variations are superposed on the tidal variations of level. The periodicities of these superposed variations range from about 8 mins. to over 2 hours, but in general all the stations show one period of about 40 mins., which probably corresponds to a uninodal oscillation of the southern part of the Baltic stretching from east to west. The other periods observed are possibly due to local conditions at the observation stations. A. W.

1518. *Reduction of Underground Temperature Observations.* **K. Aichi.** (Phys. Math. Soc. Japan, Proc. 4. pp. 35–42, March, 1922.)—Discusses the annual temperature-wave as a train of impulses instead of the usual decomposition into simple harmonic components. The occurrence of max. or minimum temperatures at various depths is shown on this hypothesis not to coincide exactly with the values deduced for simple harmonic waves. This produces inaccuracy in the determination of diffusivity from observations of max. or minimum temperature at a depth. A direct calculation of the underground temperature from the surface temperature is given, and the accuracy obtainable by taking the means for many years is discussed. A. W. L.

1519. *Co-Tidal Lines.* **E. Fichot.** (Comptes Rendus, 174. pp. 743-745, March 13, 1922.)—The angular velocity and the direction of rotation of co-tidal lines about a point of no tide, as affected by the rotation of the earth, are worked out in the case of a canal of constant depth, open at both ends, and traversed in both directions by waves of the same amplitude and velocity. These conditions are approximated to in the North Sea. W. A. R.

1520. *Types of Earthquakes and their Areas of Disturbance.* **S. Nakamura.** (Meteorolog. Soc. of Japan, J. Feb., 1922. Nature, 109. pp. 593-594, May 6, 1922.—Abstract.)—In the Miyosi earthquake the disturbed area was divided into four quadrants by two slightly curved lines. In the S.E. quadrant the first movement was inwards; in the N.E. and S.W. quadrants outwards; and the remaining quadrant was occupied by the sea. A second type is exemplified by the Oomati earthquake, in which the first movement on the S.E. side of the epicentre was inwards, and on the N.W. side outwards. There appears to be also a third type in which movement is mainly inwards in all directions from the epicentre. W. A. R.

1521. *Earthquake Waves.* **S. W. Visser.** Nature, 109. p. 283, March 2, 1922.—Abstract.)—A detailed examination of the records of earthquakes occurring near Batavia enabled new and more complete tables of the corrections to the times of transit of the primary and secondary waves to be drawn up. The corrections of the primary times are most conspicuous in the range from 50° to 100°, being an increase of as much as 10 secs. at a distance of 60°. With regard to secondary times there is a decrease for arcs less than 50°, an increase for arcs up to 70°, and a marked decrease for arcs greater than 80°. The results of the investigations agree with Knott's conclusions as to the interior of the earth, but the form of the waves will have to be recalculated. The conclusion that primary waves cease to be recorded at distances greater than 110° is supported, but evidence is found that they reappear beyond 140° with a retarded time of transit. W. A. R.

1522. *Earthquakes; Diurnal Periodicity.* **C. Davison.** (Phil. Mag. 43. pp. 878-885, May, 1922.)—(1) With one exception the amplitude of the diurnal period is much greater in the weak than in the strong earthquakes. (2) In strong earthquakes the max. epoch occurs about noon at Kew, Edinburgh, San Fernando, and Cape of Good Hope; midnight at Toronto and Victoria, B.C.; afternoon at Cordova. (3) In the weak earthquakes, maximum-epoch occurs at about noon at Kew, Toronto, Victoria, Cape of Good Hope; midnight at San Fernando and Cordova; at Edinburgh, at noon in winter and about midnight in summer. (4) In some of the places there is thus an inversion of the epochs of strong and weak earthquakes. (5) In Japan the diurnal periodicity of ordinary earthquakes may have more than one cause, but that of after shocks is probably due to variation of barometric pressure. The effects will probably be influenced by the type of fault along which slip occurs. [See Abs. 1698 (1921).] W. A. R.

1523. *Pressure Due to Crystallisation (Pressure on the Earth's Crust).* **G. W. Morey.** (Washington Acad. Sci., J. 12. pp. 219–230, May 4, 1922.)—When a system composed of volatile and non-volatile components is cooled, crystallisation will take place at a lower temperature than the freezing-point of the non-volatile component by an amount corresponding to the amount of volatile material present; the corresponding three-phase pressure increases rapidly as the temperature is lowered from the melting-point of the salt. In systems in which the non-volatile material is molten silicates (magma) and in which the pressure required to retain any considerable proportion of water is large, a comparatively small amount of crystallisation will result in a large increase of pressure. When a magma containing water cools, with consequent crystallisation and development of high pressure, under an incompetent crust, a release of pressure will take place, which may be catastrophic in violence or take the form of a succession of mild explosions. If the magma cool under a competent crust, the pressure will rise to a maximum and then decrease, probably without at any time showing critical phenomena. W. A. R.

1524. *Microseismograms.* **J. B. Dale.** (Phil. Mag. 43. pp. 463–471, March, 1922.)—Microseismograms are records traced by seismographs when undisturbed by earthquakes. These motions fall into two classes: one wholly irregular due to the wind, and the other, dealt with in the paper, persists throughout the year, more marked in winter than in summer. The records are smooth sinusoidal curves of fairly constant period, with an amplitude that changes at irregular intervals, whose average length is a minute. The period of oscillations ranges from 4 to 8 secs.—the longer period and greater amplitudes occurring in the winter. A curve obtained at Pulkova, 1910, is analysed. The results agree sufficiently well to establish the existence of at least two simple harmonic components, but the differences between various solutions are so large that it cannot be said whether more are involved. More definite results could only be obtained if some means were found for further magnifying the movement. W. A. R.

1525. *Astronomical Proofs of Relativity.* **E. Esclangon.** (Bull. Astronomique, 1. 6. pp. 303–329, 1922.)—While physicists are paying attention to the consequences, open to verification, of theories of relativity, and astronomers plan to repeat and multiply the test observations by which the theories are supposed to stand or fall, there are not wanting some idolaters, who in their fervour for the new cult, attempt to extend its application beyond the domain of physics into that of biology and mental process. The author considers the difficulties surrounding the definition of "time," according as it is measured mechanically by clockwork, or by the recurrence of natural phenomena such as stellar eclipses, by pulse beats, by thought transmission, or by light-vibrations or chemical reactions, which will yield very different results when applied to any problem of time or velocity determination. He contrasts this with the simplicity of measures of distance. He gives some examples of attempts made to show an apparent reversal of the order of events, according to the movement of the observers, and contrasts the cases of periodic phenomena and of irreversible chemical or biological processes, and points out other difficulties which at present prevent the exact proof of the conclusions founded on relativity, on general principles only. He then turns to the astronomical tests, dealing successively with the motion of Mercury's perihelion, with the bending of light passing the sun, and with the displacement of spectral lines. While not ignoring the fact that a law resting on a few positive instances cannot be accepted as proved, though a single instance might suffice to disprove it, he is willing to submit to the result of these three tests. Newcomb's residual of 43″ in the motion of Mercury's perihelion cannot be regarded as a final value, as any correction of the data concerned (*e.g.* the mass of Venus) will mean an alteration in the amount of the residual. Einstein's predicted 43″ is therefore suspiciously close. There is another objection to the soundness of the claim that Einstein's hypothesis accounts for the outstanding residual in the motion of Mercury's perihelion. If Newton's theory is incorrect, it must not be used to account for 93 % of the motion while Einstein's is applied to explain the other 7 %. Newton must be ignored altogether, and Einstein's formulæ must provide completely for the whole motion before it can claim acceptance on such grounds. The first criterion, therefore, is not definitely acceptable as yet. The second, based on the eclipse photographs at Sobral and Principe, is on a different footing. It is evident that in the nature of the observations a much greater quantity must be obtained in order to reduce the effects of accidental and instrumental errors. So far as it goes the Einstein theory points to a discordance of the same order of magnitude as that found. Empirical formulæ can be found to give closer accordance, and the author gives examples to show that the Einstein theory from this point of view does not make the closest approximation. Moreover, if the Einstein effect be the true one, it should be strictly radial, and there is nevertheless some evidence of a displacement perpendicular to the sun's equator. The author regrets that the eclipses of 1922 and 1923 are less favourable than that of 1919, as the May sun is in a richer region of stars, but he points out various ways in which that drawback can be surmounted. He is arranging for experimental work at Algiers in preparation for the 1923 eclipse, using an astrographic telescope, so as to eliminate the defects introduced by the use of a cœlostat. He suggests, for instance, that fainter stars may be made available, and that the sun need not be in the centre of the field, so that brighter though more distant stars may be included, which would serve to check the accuracy of the plate, though too far off to show a measurable Einstein displacement. He thinks many years may elapse before this criterion gives a definite result. There remains the third test, the displacement of rays in the solar spectrum as compared with similar rays from a terrestrial source. Here the great difficulty appears to be that similar displacements have been attributed to pressure, and that the pressure in the solar atmosphere is not accurately known. The cyanogen bands are supposed to be insensible to this pressure difference, but it is not easy to be sure of this. He discusses Perot's work and that of Fabry and Buisson, to determine the effect of pressure changes on certain lines and to obtain by inference the pressure in the solar spectrum. This third test he considers the most promising, as work can be carried on at any time without waiting for eclipses. The possibility of Einstein effects being observed when light from a star passes close to one of the stars whose mass is much greater than that of the sun is mentioned, but any such observation must be extremely rare, and cannot be counted upon. W. W. B.

1526. *An Elbow-Telescope for the Method of Equal Altitudes.* **A. de la Baume Pluvinel.** (Comptes Rendus, 174. pp. 535–536, Feb. 20, 1922.)—Having regard to the advantages of Gauss' method of equal altitudes in dispensing with circle readings, the author describes a telescope for the purpose. The two arms make equal angles with the vertical, and are in a vertical plane. At the elbow is a mercury trough. N being the nodal point behind the objective, M the point on the surface of the mercury where the axes of the tubes intersect, and F the intersection of the cross-series behind the eyepiece, NM should = MF, and M should be in the centre of the trough. The author shows that an accidental tilt of the instrument will not displace a star image from the cross wire. He considers the possible errors of manufacture; and finds that if k is the distance of M from the centre of the trough and h the difference between the lengths NM and MF, α the angle of displacement, and f the focal distance of the objective, the maximum error when the arms are inclined at 30° to the vertical is $\epsilon = \alpha/f(h + k)$. Considering that the instrument can be levelled accurately to 1′, h and k may be a millimetre in error, without altering the zenith distance more than $0''\cdot 15$. By employing a collimator outside the objective, the instrument can be adjusted so that a tilt of 10′ has no effect. W. W. B.

1527. *Temperature Regulation of Spectrograph and Mirror.* **J. S. Plaskett.** (Roy. Astron. Soc. Canada, J. 16. pp. 91–100, March, 1922.)—Early spectrographs were unprovided with any temperature control, but its importance was soon recognised. The author mentions early devices employed for the purpose, but when considering the question for the spectrograph to be used with the 72-in. telescope he required a more sensitive form. The success of the Callendar recorder used with the standard Riefler clock at the Dominion Observatory, Ottawa, and the adaptation of it for the Cape spectrograph, encouraged the adoption of a modified form of it for the Victoria telescope. A full account is given of the design chosen in 1916, but not actually received until Feb. 1921. Its control of temperature is associated with a pen recorder, working on a very open scale, which can be read to hundredths of degrees, and as the resistances are fine Pt wires, the response to changing temperature is very quick, moreover the wires can be so distributed about the spectrograph that all parts of it share in the control, and not merely one portion, as in the case of an ordinary thermostat. The advantages are fully discussed, and a typical register is given and its various curves explained. It shows the temperature variation for the dome and mirror, as well as for the spectrograph. The author discusses further possible refinements, but gives reasons for disregarding the residuals due to the slight difference of east and west mirror thermometers. W. W. B.

1528. *Comparison of Speed of Blue and Yellow Light.* (Harvard Coll. Obs. Bull. No. 763. Nature, 109. p. 318, March 9, 1922.—Abstract.)—The globular cluster M. 5 Libræ was photographed on plates sensitised for blue and others for yellow light. On the average the times of phases were later in the blue light by 35 secs., with a probable error of 70 secs. Five different methods give a distance of about 40,000 light-years. Only

M. 13 Herculis is nearer than this of the clusters north of the equator. On these figures the speeds of blue and yellow light do not differ by more than one part in ten thousand millions as a maximum. Any absorbing medium would cause the speeds to differ, so this affords an upper limit to the amount. W. W. B.

1529. *Sun's Rotation from Spectroheliograms.* (Yerkes Observat. 3. Part 3. Nature, 109. p. 422, April 1, 1922.—Abstract.)—Spectroheliograms taken at Yerkes Observatory between 1903 and 1909 were measured by projecting the lantern image on to a globe marked with latitude and longitude circles, and tilted into the requisite position. Mean daily motion in

Northern hemisphere $\xi = 11^\circ\cdot 107 + 3^\circ\cdot 449 \cos^2 \phi$
Southern „ $\xi = 12^\circ\cdot 143 + 2^\circ\cdot 408 \cos^2 \phi$

The differential motion of flocculi round spots shows an anticyclonic whirl for single spots, but cyclonic for the leading spots of bipolar groups. An increase of angular velocity is noted through the series (1) Reversing layer, (2) Sun-spots, (3) Faculæ and flocculi, (4) λ 4227, and (5) H_α, the whole acceleration being 1° per day. The present paper provides for (3) only of the above series. W. W. B.

1530. *Deflection of a Ray of Light in the Solar Gravitational Field.* **F. D. Murnaghan.** (Phil. Mag. 43. pp. 580–588, March, 1922.)—A mathematical paper, attempting a more direct treatment of the subject than is given in Eddington's " Report on the Relativity Theory of Gravitation." The exact significance of the Fermat (or Huyghens') Least-Time Principle is studied. A determination of the elliptic integral giving the displacement, and an evaluation of the elliptic integral for the deflection are developed, from which Einstein's prediction of a deflection of about $1''\cdot 73$ for a ray which just grazes the sun is calculated. A. B. C. L.

1531. *Pressure in Solar Atmosphere.* **A. Perot.** (Comptes Rendus, 174. pp. 933–934, April 3, 1922. J. de Physique et le Radium, 3. pp. 101–109, April, 1922.)—The author's method of inferring the pressure in gaseous masses from differential measures of radiations differently affected by pressure [see Abs. 1024 (1921)], enables a value to be obtained independent of such homogeneous effects as those of Doppler and Einstein. This method was applied by the author to the *b* group of Mg lines in the chromosphere, where practically no pressure was indicated, next by Salet to the Fe lines in the chromosphere and in a few stars, finding in the former case a pressure of some tenths of an atmosphere; then, by Fabry and Buisson to the Fe lines in the reversing layer to test the Einstein theory, their result pointing to a very feeble pressure instead of several atmospheres. The author now returns to the study of these Fe lines. He selects $\lambda\lambda$4219·5, 4227·6, 4233·8, 4236·1, and 4294·3, of which the first and last have a very small pressure coefficient, while the other three have a large one. Taking these lines in pairs, under pressures varying from 4 cm. to 76 cm. of mercury, and comparing the differences with those in the solar spectrum and in a terrestrial source at atmospheric pressure, he deduces for the solar lines a mean pressure of 34 cm. of mercury, or nearly ½ atmo. Such a pressure, he says, involves a low velocity for electrons, and this agrees with the fact that he has not found any descending velocity for Fe vapour in the chromosphere, its law of rotation being very nearly, if not quite, identical with that of sun-spots. W. W. B.

1532. *The Eötvös-Effect in a Moving Solar System.* **I[mre] Szolnoki.** (Ann. d. Physik, 67. 1. pp. 73–76, April 12, 1922.)—Eötvös theoretically demonstrated changes of weight of bodies on the earth for a solar system at rest. The importance of this work has been more recently shown by S. Rybâr and D. Pekâr in 1918 and 1919. In the case of a rotating solar system other results follow. The change in solar attraction on the earth is according to Eötvös $\Delta g_s = -2\Omega \,.\, dy/dt$, where Ω = the relative angular velocity of earth and sun, and dy/dt = the relative orbital speed. Calculations are given of the values of Δg_s at solstitial and equinoctial points in the earth's orbit, the greatest value found being in c.g.s. units 0·011 at latitude 47°. P. E. S.

1533. *The Theory of Ionisation and the Sun-Spot Spectrum.* **H. N. Russell.** (Mt. Wilson Observat., Contrib. No. 225. Astrophys. J. 55. pp. 119–144, March, 1922.)—*Saha's Theory of Temperature Ionisation.*—Strong *evidence in favour of the theory* is afforded by a comparison of the sun-spot and the solar spectrum, since the predictions of the theory with reference to the relative intensity in the hotter and the cooler spectrum, of lines associated with ionised and un-ionised atoms, are in general agreement with the facts. However, discrepancies such as the presence of too large a fraction of ionised Ba atoms, suggest the need of some modification of the theory.

Relative Intensity in Solar and Sun-Spot Spectra of Series Lines.—The lines of the *alkali metals* (all of which are due to the neutral atoms) are *greatly strengthened* in the spot spectrum. Na (I = 5·11 volts) exhibits its principal and subordinate series, K (4·32) the principal series alone, and Li (5·37) and Rb (4·16) the leading pair of the principal series, and only in the spot spectrum. The corresponding lines of Cs are out of reach in the infra-red.

Among the *alkaline earths* the lines of the *neutral atom* for Ca (6·08 volts) are strengthened in the spots to a degree which is greatest for the principal series and least for the combination series. The corresponding lines of Sr (5·67) are faint in the sun and much strengthened in spots. For Ba (5·12 volts) they are absent both in sun and spots. The *enhanced lines* arising from the ionised atoms (Ca +, Sr +, Ba +) are strong in both spectra.

For Mg (7·65 volts) the lines of the *neutral atom* are little affected, except that the fundamental line $1S - 2p_2$ is stronger, while for Zn (9·4 volts) the arc lines are much weaker in the spot spectrum.

These results are all in agreement with Saha's theory. The lines of Li and Ba, however, are much weaker than the theory indicates.

Relative Intensity of Arc and Enhanced Lines.—It is pointed out that enhanced lines of easily ionised elements can be produced with less excitation than arc lines of difficultly ionised elements. This fact explains many apparent anomalies in astrophysical spectra.

Ionisation Potential of the Elements as a Function of Atomic Number.—Since from the relative behaviour in sun, spot, and furnace spectra, of the lines of Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, and Zn, the elements as arranged in the order of their atomic numbers, are progressively more difficult to excite spectroscopically, the ionisation potential probably increases regularly from 6 volts for Ca to 9·4 volts for Zn, and this result combined with other data suggests that, *in general*, the ionisation potential is a periodic function of the atomic number.

Identification of certain Solar Lines.—Lines of Rb have been detected in the sun for the first time. Also several faint Na lines have been identified and Datta's identifications of Na and K lines have been partly confirmed, partly not.

Tables of the series lines of Li, Na, K, Rb, Cs, Ca, Sr, Ba, Mg, and Zn are given with intensities in sun and spot, and wave-lengths in international units to 0·01 Å. AUTHOR.

1534. *Spectrum of the Corona at the Total Eclipse of June* 8, 1918. **V. M. Slipher.** (Astrophys. J. 55. pp. 73–84, March, 1922.)—The Lowell Observatory party, located near Syracuse, Kansas, obtained photographs with the following four spectrographs: (1) with single prism, 49-cm. camera, slit E.–W.; (2) with single prism, 8·3-cm. camera, slit N.–S., then E.–W.; (3) with three prisms, 9-in. camera, slit E.–W.; (4) with three prisms, edges N.–S., 47-cm. camera, no slit. Weather conditions somewhat interfered with preparations; and thin haze veiled the sun during the eclipse, causing some scattering of light that rendered less certain the interpretation of some of the results. Yet useful plates were obtained with all the instruments. These show the usual prominence and chromospheric lines, the chief lines of coronium, the continuous spectrum of the corona, with weak dark lines whose origin is not quite certain; and strips of continuous spectrum coincident with certain prominences and sections of the inner corona uncovered by depressions of the moon's limb.

Distribution of Coronium.—The coronium line λ5303·0 indicates that this substance extended about a solar diameter above the sun's surface. The slitless spectra show many condensations in the green coronium ring. These are not related to the prominences. Coronium was fairly abundant generally along the sun's limb under those major extensions of the outer corona, and scarce where the coronal rays typical of the polar regions occupied the limb. AUTHOR.

1535. *General Relativity Theory and the Solar Spectrum.* **W. H. Julius** and **P. H. Van Cittert.** (K. Akad. Amsterdam, Proc. 23. 4. pp. 522–532, 1921.)—Admitting that Einstein's theory has passed two of the three tests (motion of Mercury's perihelion and displacements of rays, passing close to the sun), there remains the systematic displacement of the Fraunhofer lines towards the red, of which evidence is still wanting. Several attempts have been made [see Abs. 1171 (1920)] to group the observations in such a way as to eliminate certain other causes which are capable of producing displacements of the same order of magnitude, such as radial velocity, pressure, and anomalous dispersion, since it is these and not the small size of the quantity sought that stand in the way. The authors comment on the disagreement between the results of the attempts made by different observers, such as St. John on the one side and Grebe and Bachem on the other, and suggest anomalous dispersion as a sufficient explanation of all the obscurities. Julius has ever since 1904 been calling attention to this principle by which he purports to explain practically all solar phenomena; and he and his co-author now adduce fresh evidence in support of the view that anomalous dispersion governs the distribution of light in the Fraunhofer lines. They consider that dispersion bands partially mask fine lines, and appear to shift them unsymmetrically. They examine Adams's data for limb-centre displacements in the sun, distinguishing 26 lines with effective companions on the red side and 24 with effective companions on the violet side. The average departures of these affected lines from the curve of mean displacements is − 0·0017 Å. for those on the red side and + ·0015 Å. for those on the violet side. These displacements the authors show to be much greater than they should be if no systematic influence were at work. They work out the odds at 500 to 1. Considering the possible effect of subjective and objective errors as affecting this, they come to the conclusion that these amount to not more than 1 %, and will be practically the same for the sun's limb and for the centre. They thus consider the case proved for the mutual repulsion of neighbouring lines, and also that the observational data as yet available contradict the inference that the Fraunhofer lines should be displaced by gravitation. In conclusion they turn to the comparison between the sun and terrestrial sources, and find that the theoretical displacements required by Einstein are so much greater than those found that they cannot be attributed to accidental error. W. W. B.

1536. *Planet Observations at Sétif.* **R. Jarry-Desloges.** (Nature, 109. p. 386, March 23, 1922.)—The observatory was established in Algiers specially for lunar and planetary observation, and the author has published a large illustrated volume of studies of these objects. *Mercury* by day was found as easy as Mars, and the rotation period comes out at 88 days in accord with the results of Schiaparelli and Lowell. In contrast with other observers, the author does find evidence of occasional cloud or mist veiling and modifying the appearance of markings. As the light and heat received from the sun in perihelion and aphelion are in the ratio of 9 to 4, the cloud and precipitation conditions will be greatly affected. The disc, generally of a rosy colour, shows broad, curved dusky streaks, 60° in length with a few larger spots. *Uranus* shows markings like those of Saturn, with a bright equatorial belt and bright belts in N. and S. temperate zones, but these are not strictly parallel to the equator. The markings are curved and inclined. Dark belts were seen on *Neptune* in 1914. Neptune's satellite Triton was generally an easier object than Mimas. Drawings of *Saturn* show notches in the outline of the Cassini division and in that of the crêpe ring. The rotation of *Venus* could not be determined. W. W. B.

1537. *Theory of Comets' Tails.* **A. Belopolsky.** (Observatory, 45. pp. 110–112, April, 1922.)—The author states that according to Zöllner's electrical theory, and also from the theory of light-pressure on molecules of gas, we get the relation $r\sigma(1-\mu) = \text{const.} = 0{\cdot}0001374\,\delta\,.\,\Delta$, where r is the radius of the molecule and σ its density; δ the density of its surface electricity, and Δ of that on the sun's surface, and μ the attraction at unit distance so that $1-\mu$ is the repulsive force. For light-pressure the right-hand member becomes $3/4 \times 1/10^4$. Under homogeneous conditions of temperature and pressure σ is proportional to the atomic weight of the gas, m, so that $m(1-\mu) = \text{const.}$ For different tails of comet Morehouse values of μ were found, 20, 40, 80, 100, especially 40, and a few higher ones, while a value of 193 was found for Halley's comet.

Assuming that the value 40 corresponds to the predominant CO in the case of Morehouse we have $m(1 - \mu) = 28 \times 40 = 1120$, but comparing values of the constant from other elements we obtain a mean value 1148. If we follow Rutherford and take N to be a product of He and H we obtain the fifth column in the annexed table. Alternatively by bringing in J. J. Thomson's hypothetical element X of at. wt. 3 we obtain the sixth column.

m.	μ Calc.	μ Obs.	Element.	Molecule (1).	Molecule (2).	Comet.
56	21	20	$\left\{\begin{matrix}(CO)_2 \text{ or} \\ C_2N_2\end{matrix}\right\}$	$4(3He + H_2)$	$4(4X + H_2)$	Morehouse
28	41	40	CO	$2(3He + H_2)$	$2(4X + H_2)$	,,
14	82	80	N	$1(3He + H_2)$	$1(4X + H_2)$	,,
12	96	100	C	$2(He + H_2)$	4X	,,
9	128	130	—	—	3X	,,
6	192	193	—	$1(He + H_2)$	2X	Halley
4	(289)	(260)	He	He	He	Morehouse
3	(384)	(376)	—	—	7X	,,
[2	574	—]	—	[H]	[H]	—

Thus all the tails will consist of polymers of X or of $4X + H_2$ (except for H or He simple tails, if such exist). For tails of Bredikhine's 2nd and 3rd type very little is known except from comets 1882 I and II. The Na found may be CO under pressure as suggested by Fowler. Bredikhine's figures for comet 1882 I give $1 - \mu_2 = 0 \cdot 8$ and $1 - \mu_3 = 0 \cdot 2$. Thus we have:

$$\begin{aligned}(1 - \mu_2)(C_2N_2) &= 0 \cdot 8 \times 52 = 42 \\ ,, \quad (CO_2) &= 0 \cdot 8 \times 56 = 45 \\ ,, \quad C_2H_2 &= 1 \cdot 6 \times 26 = 42 \\ ,, \quad C_2H_4 &= 1 \cdot 6 \times 28 = 45 \\ ,, \quad Na &= 2 \cdot 0 \times 23 = 46 \\ \text{Mean} \ldots\ldots & \quad 45\end{aligned}$$

$$\begin{aligned}(1 - \mu_3) \times C_2N_2 &= 0 \cdot 2 \times 56 = 11 \\ ,, \quad \times (CO)_2 &= 0 \cdot 2 \times 56 = 11\end{aligned}$$

These values 45 and 11 are very small compared with 1148, which suggests that in the tails of the 2nd and 3rd type the molecules are polymers of greater atomic weight than in the first type. W. W. B.

1538. *M-type Spectra with Bright Lines.* **C. P. Butler.** (Observatory, 45. pp. 15–17, Jan., 1922.)—Particulars are given of recent discoveries in relation to stars supposed to belong to the M class. R Aquarii, listed as M*d*, showed in the great Mount Wilson reflector the spectrum of Nb among its lines. From a Lick photograph, which showed Nb line 3868·9 but not 3967·5, a suspicion was aroused that the Ca absorption line 3968 masked the latter, so that Ca vapour might surround the star. T Coronæ (Nova Coronæ of 1866), which is regarded as a case of brightening of a star already visible, has recently yielded TiO absorption lines, and He 4686. A Lick spectrograph suggests a typical M*a* star. The author discusses the differences between old and new observations, and hints that the recently discovered lines, showing similarity between red M stars and the gaseous nebulæ and Wolf-Rayet stars at the other end of the Harvard scale, may be the first indication that the order of evolution is cyclic and continuous, instead of merely transitional between two varieties of unknown chaos. W. W. B.

1539. *Variable Nebulæ.* **H. K. Shaw.** (Helwân Observat. Bull. No. 20. Observatory, 45. p. 26, Jan., 1922.)—A further account is given of the variable nebula N.G.C. 6729, attached to R Coronæ and reaching at times beyond T Coronæ (Nova Coronæ 1866). It seems to provide an intermediate type between a nova and an irregular variable. Rings and S-shaped curves appear and disappear in the nebulous matter. Brown's suggestion that we see a drift of nebulous matter through the region occupied by T Coronæ and R Coronæ involves the difficulty that velocities are involved of the order of that of light. Presumably T Coronæ blazed up on first colliding with the nebula, but has now reached a thinner stream or else changed its velocity very much in relation to the stream. The spectrum of T Coronæ is rather like that of Hubble's variable nebula, but not sufficiently so to identify them as of the same class.

W. W. B.

1540. *Andromeda Nebula, M. 33, and Nubecula Major.* **J. H. Reynolds.** (Observatory, 44. pp. 368–372, Dec., 1921.)—The first two of these are the spirals with largest known angular diameter, and are within ten degrees of each other. M. 33 is far more condensed than the Andromeda nebula, and hence may be vastly older. The Andromeda nebula shows recession of 230 km./sec., and a bright condensation in M. 33 shows a recession of 278 km./sec., but the stars in the nebula are too faint for spectroscopic examination. As the light of a nebula is not diminished with distance, while that of the stars is, a distant nebula cannot be surveyed by means of its stars. The author gives instances of this; and on this consideration bases an explanation of the great difference between the two nebulæ. He considers also other difficulties, such as the prevalence of solar type among spiral nebulæ, and suggests the absence of a photosphere as vitiating deductions usually drawn. Temperature conditions seem to govern the type, as in all theories. Special photographs taken at Helwân with the 30-in. reflector show very little ultra-violet in the Andromeda nebula. The author considers it likely that the transition from the uncondensed (Andromeda) type to the condensed (M. 33) is attended by the appearance of gaseous spectra. He gives examples of other spirals of varying degrees of condensation, and proceeds to the consideration of R. E. Wilson's work on the greater Magellanic cloud, which Wilson suggests may be a typical spiral nebula, nearer to us than most, if not all, of the other spirals. The author, while disinclined to accept it as a typical spiral, draws attention to the fact that it is in the southern galactic hemisphere, which contains the five largest spirals in the sky. He thinks Nubecula Major may lie comparatively close to the galactic system, and that it is not very large in comparison, giving reasons for placing it at a distance of about 1000 light-years. W. W. B.

1541. *Class A Stars in Solar Cluster.* **H. Shapley** and **A. J. Cannon.** (Harvard Circ. No. 229. Nature, 109. p. 386, March 23, 1922.—Abstract.)—

J. Herschel and Gould noticed a zone of bright stars making a small angle with the Milky Way. Charlier's local B stars mark out nearly the same great circle. 2450 stars down to 6¼ magnitude of types B8, B9, A0, A2, A3, are plotted by the authors in galactic coordinates on an equal-area projection. Crosses mark the median galactic latitudes of the stars in each 10° of longitude. The resulting smooth curve shows maxima and minima as follows: Long. 50°, Lat. + 5°; 195°, − 6°; 300°, + 7°; and 335°, − 4°. The results appear to them to confirm the local cluster, and also to suggest a disturbing factor, possibly a separate cluster about Corona Australis. They propose to extend the investigation to "later" types, for which spectroscopic parallaxes can be found. W. W. B.

1542. *Distances of Globular Clusters.* **A. C. D. Crommelin.** (Observatory, 45. pp. 138–142, May, 1922.)—Shapley's determinations of the distances of globular clusters, 36,000 to 210,000 light-years, have been challenged by Schouten, who wishes to divide the figures by 7·6, by Curtis, who thinks them 10 times too large; and by Kapteyn and Van Rhijn, whose reduction figure agrees with Schouten's, obtained in a different manner. The author thinks that Schouten and Curtis have gone too far in assuming a close similarity between the magnitude distribution in clusters and in the general solar swarm, which is much less concentrated and probably much less homogeneous. In extending a survey radially, naturally more and more of the faint stars drop out of sight, and the mean absolute magnitude goes up; whereas in a globular cluster, a small range of distance is quite plausible. This difference might be evaded by omitting some of the small stars near the sun and introducing more at a distance, but this cannot be done with any confidence. The argument of Kapteyn and Van Rhijn depends on statistics of known Cepheids, which they divide into short- and long-period, with the limiting period of 16 hours between the classes. The short-period ones supply them with a mean parallax 7·6 times as great as Shapley's, and the author thinks this is in the right direction. The long-period ones seem to confirm Shapley's figures, or even to push the stars still further away. These are much less frequent in the clusters, but Kapteyn and Van Rhijn were premature in their argument that the absence of short-period variables in the small Magellanic cloud proves the identity in character of the short-period cluster Cepheids and the galactic Cepheids of similar period; as it has since been found that several short-period Cepheids are shown on long-exposure plates of the Magellanic cloud. The author suggests three alternatives: (1) To bring the Magellanic cloud also 7·6 times nearer, thus spoiling the case of the longer-period Cepheids, and also making the absolute magnitude of the B stars improbably low. (2) To reject the comparison between the cluster Cepheids and those in the galaxy, and (3) to assume that the short-period Cepheids do not belong to the cloud, but are simply projected against it as a background. None of these suggestions satisfy him, but he is willing to concede that Shapley's distances may possibly require division by some factor, but probably not one greater than 2, so that the suggested 7·6 and 10 are unacceptable to him. W. W. B.

1543. *Parallaxes of Three Wolf-Rayet Stars.* **L. E. Hill.** (Astron. J. 34. p. 38, March 16, 1922.)—These stars were placed at Van Maanen's request on the parallax programme of Dearborn Observatory. The results show considerable differences from previous determinations by van Maanen and Kapteyn. The stars are: B.D. + 35° 4001 and 4013, and + 36° 3956. W. W. B.

1544. *Parallaxes of 57 Stars.* **M. Booth** and **F. Schlesinger.** (Astron. J. 34. pp. 31–34, March 16, 1922.)—The photographic plates were secured at Allegheny Observatory, and were measured and reduced at Yale Observatory by Miss Booth. The numeration follows on previous Allegheny lists. The average probable error of a parallax is 0″·0084. Most of the stars are difficult for some reason or other, in some cases because the star is a binary. Full details will be given in a Memoir of the National Academy of Sciences. The largest parallax in the list appears to belong to one of the components of 44 Boötis, + 0″·078 ± 0″·009. W. W. B.

1545. *Stellar Magnitude of Ringless Saturn.* **J. van der Bilt.** (Astron. Inst. Netherlands, Bull. No. 6. Nature, 109. p. 352, March 16, 1922.—Abstract.)—Using revised magnitudes of comparison stars Capella, Vega, Procyon, Spica, Pollux, Regulus, and Polaris, the author obtains for Saturn in opposition (ringless) 0·84 mag. (Müller's value, 0·877 mag.) He deduces the planets' albedo, with the idea that similar determinations, when rings are wide open, will determine their albedo, and give a clue to their constitution. He also investigates the effect of phase angle on magnitude, and finds it to be 0·050 mag. for 1° change in the angle Sun-Saturn-Earth, in good accord with other determinations. W. W. B.

1546. *Effective Temperature of* 16 *Stars, Estimated from Energy-Distribution in Complete Spectrum.* **W. W. Coblentz.** (Nat. Acad. Sci., Proc. 8. pp. 49–53, March, 1922.)—The differences in estimates of stellar temperatures by different methods are probably due to only part of the spectrum being employed. A comparison made at Lick Observatory showed that red stars emit 2½ to 3 times as much *total* radiation as blue stars of the same magnitude. An independent check was obtained by means of a 1-cm. cell of water with quartz windows. This showed that of *total* radiation blue stars have about twice as much *visible* radiation as yellow stars, and three times as much as red stars. The present paper deals with results obtained by means of a series of transmission screens (red and yellow glass, quartz, and water) placed in front of a vacuum thermocouple and used as the radiometer. With these in combination it was possible to obtain radiation intensity in the spectrum at $0·3\,\mu$ to $0·43\,\mu$; $0·43\,\mu$ to $0·60\,\mu$; $0·60\,\mu$ to $1·4\,\mu$; $1·4\,\mu$ to $4·1\,\mu$, and $4·1\,\mu$ to $10\,\mu$.

In Class B and A stars the max. radiation intensity is in the ultraviolet ($0·3$ to $0·4\,\mu$), while in the cooler K and M stars it lies between $0·7$ to $0·9\,\mu$ in the infra-red. Thus the "black-body" temperature varies from 3000° C. for red M stars to 10,000° for blue B stars. The details of the method are given, and a comparison of the results with those of other observers. The author's data were obtained at the Lowell Observatory, and the list of stars includes Pollux, Antaris, Altair. Aldebaran, Betelgeux, Capella, and Arcturus. W. W. B.

1547. *Light-Curve of Nova Cygni,* 1920. (Urania Obs. Copenhagen, Publ. No. 3. Nature, 109. p. 386, March 23, 1922.—Abstract.)—The

Nova was discovered early and rose comparatively slowly to maximum. This is confirmed by photographs taken before discovery. The apex, at 1·8 mag., is sharp, and the subsequent fall rapid, 2½ magnitudes in ten days, then slower but steady for 3 months, when it began to be oscillatory. After another 3 months the oscillation increased, and the diminution became slower. In the year ending 1921 September the mean magnitude fell from 8·6 to 9·7 Colour observations were less consistent. Colour was less than 2 [scale 0 (white) to 10 (red)] at discovery, and was yellow at maximum; in three months it rose to 6 or 7 on the scale. A table of photographic magnitudes for 6 months is given, but does not indicate the increasing redness noted. W. W. B.

1548. *New Variable Star in Cygnus.* **A. S. Williams.** (Roy. Astron. Soc., M.N. 82. pp. 300–302, March, 1922.)—This star, discovered by the author in 1905, has not received recognition as a variable. Including observations from Oct. 1921 to Jan. 1922, the period comes out approximately 15h. 8m. 54s., and the variation from principal minimum 10·42, to first maximum 9·93, secondary minimum 10·15, and second maximum 9·94. The light-curve is appended, of the general form of the β Lyræ type, with eclipse not quite total. The residuals between curve and observation are nearly all very small. W. W. B.

1549. *Unique Long-period Variable.* **W. J. S. Lockyer.** (Nature, 109. p. 530, April 22, 1922.)—The author gives a summary of the successive discoveries made in connection with R Aquarii (range of magnitude 6·2 to 11, Class Md, period 385·5 days). Normally the spectrum of the Md star shows bright H lines and TiO_2 absorption flutings on a continuous spectrum, indicating a low temperature. Merrill, with the 100-in. Mount Wilson reflector, found several other bright lines, characteristic of gaseous nebulæ. No " cool " star had previously shown this phenomenon. These nebular lines remain almost constant, while the Md lines vary through a large range in the star's period. It seems, therefore, that the star and nebula are independent, though other observations point to a close connection. Lampland at the Lowell Observatory has taken a photograph showing that the star is in the centre of a mass of nebulous matter, forming an oval-shaped, elongated figure of arcs of nebular filaments, with the star symmetrically placed in the centre. The nebulosity shown is similar to that of N.G.C. 5921, which is called by H. D. Curtis a ϕ-type spiral nebula. The author urges the importance of long-exposure photographs with powerful instruments, whenever nebular lines appear in a star, to test the presence of nebulosity.
W. W. B.

1550. *Two Spectroscopic Binary Orbits.* **W. E. Harper.** (Roy. Astron. Soc. Canada, J. 16. pp. 131–136, April, 1922.)—Boss 497, ι Trianguli, is a visual double of 3″·5 separation, stated by Burnham in his general catalogue to have its components relatively fixed, but with common proper motion of 0″·10 per annum. The magnitudes appear to be 5·5 and 6·7. The brighter star appeared to be a spectroscopic binary, so the other was also examined and found to be a spectroscopic binary, all four spectra being recorded on the plates. For the brighter star 27 plates were used. Four showed the lines single, two at each crossing point of the curve, but both spectra were measured on each of the other

23 plates. Details are given of the plates and method of measurement and comparison. The period finally adopted is 14·732 days, and the other elements are given, the mass-function for each component being practically 1·12 × sun's mass. The fainter component of the wide pair was measured on 25 plates, and the final period is given, 2·2365 days; the dimensions of the orbit about a quarter of those of the brighter star, and the mass-functions 0·906 and 0·855 times the sun's mass. For the whole system a rough mean parallax of 0″·03 is deduced; and with certain assumptions a period of 1600 years, but the author thinks this too short. **W. W. B.**

1551. *Problem of Great Stellar Distances.* **H. Shapley.** (Nat. Acad. Sci., Proc. 8. pp. 69–71, April, 1922.)—In 1904 and 1905 Miss Leavitt discovered nearly a thousand variable stars in the small Magellanic cloud from photographs taken at Arequipa. She found periods for 25 of these, varying from 127 days for one of the brightest stars in the cloud to 1·25 day for one nearly four magnitudes fainter, and deduced that the logarithm of the period increased by about 0·48 for each increase of a magnitude in the brightness. Most cluster Cepheids have periods less than a day, but it is found that the above relation is not linear. The author in the present paper gives particulars of 13 variables in the cloud with periods less than a day, though four of them are rather doubtful. The light-curves are of the typical cluster form. The mean of the median magnitudes is in close agreement with that predicted from the extended period-luminosity curve for variables of the period (mean of the 13 is 15·4 hours). The conclusion is that the cluster type variables are giant stars in the small Magellanic cloud, as well as in globular clusters, and the further inference is that they are always giants. **W. W. B.**

1552. *Diffusion and Viscosity in Giant Stars.* **S. Chapman.** (Roy. Astron. Soc., M.N. 82. pp. 292–297, March, 1922.)—If, as is now assumed, the gas in the interior of a giant star consists of free electrons and more or less ionised atoms, the forces between the gas particles are mainly electrostatic and vary according to the inverse square law of distance. In this case [see Abs. 1117 (1911)] two of the integrals occurring in the kinetic theory of diffusion and viscosity become infinite, and this point must be considered. The author restricts his inquiry to the case of encounters between two particles only, on the assumption that the distance between the lines of relative motion of two gas-particles does not exceed the mean distance between adjacent particles. The values of the two integrals mentioned prove to be independent of the distance from the centre of the star. If the nuclei are of one kind only and completely ionised, the author finds in a numerical example a value for the kinematic viscosity a hundred times that of water. The rate of diffusion of charged atoms of different weights, in the midst of the electrons which render the gas as a whole neutral, is required for a problem suggested by H. N. Russell, as to the length of time taken for atoms to diffuse from one part of a star to another region at a distance of some fraction of the radius. If in the interior there is some substance which undergoes atomic changes at high temperatures, thus liberating a large amount of energy counterbalancing loss by radiation, the rate of supply will depend on the speed with which the exhausted substance is replaced from the cooler parts of the star. Assuming this substance to be hydrogen, which will tend towards the surface, the deficiency can only be supplied by diffusion if the relative concentration of H diminishes towards the centre more rapidly than in a state of diffusive equilibrium. This is not solved in general, but a particular case is given in which a value of the diffusivity is derived.

If the giant star commenced as H only, and this is gradually transformed into heavier elements, these will remain at the centre, and the maintenance of the supply of H is simple, until the heavy gas becomes predominant in the region of transformation. Assuming the heavier gas to be He, the author finds that it will take 10^{13} years for 1 per cent. of the whole mass to diffuse across a sphere of a given radius, but the calculation is described as rough and very special. W. W. B.

1553. *Star Discs.* (3) *The Effect of Coma.* **L. C. Martin.** (Roy. Astron. Soc., M.N. 82. pp. 310–318, March, 1922.)—Conrady's theoretical results [see Abs. 1876 (1919) and 845 (1920)] are now to be practically tested, and this is a preliminary paper dealing with the method to be employed. Diagrams are given showing the form of the curves when the relative acceleration, W, is plotted against the intensity of the image on the axis of the coma patch and at various inclinations to it. There appears to be a maximum intensity at W = 210, and the high value of the intensity (0·8 of the value when no aberration is present) shows that the extreme residuals of phase aberration are less effective in destroying the concentration of the light than in the case of spherical aberration. A doublet microscopic objective has been designed, free from objectionable spherical aberration and astigmatism, while leaving a considerable residual of coma. In one case the angle of principal ray with the axis comes out at 2°·45′. A type of doublet with approximately equiconvex crown lens is likely to possess an offence against the sine condition of one part in 1000 with an aperture ratio of 1/15. These theoretical results apply only to the image found in the "Petzval" image surface. Any change of focus will introduce a considerable modification not yet investigated. W. W. B.

1554. *Eccentricity of Double-Star Orbits.* **H. N. Russell.** (Pop. Astr., March, 1922. Nature, 109. p. 560, April 29, 1922.—Abstract.)—It is possible to deduce average eccentricities by statistical methods even in the case of long-period systems only observed through a small arc of their orbits. The angle between the tangent and radius vector must be noted, and the observed distribution of angles compared with that resulting from different assumed values of the eccentricity. From observations of 750 pairs he deduces a mean eccentricity rather greater than 0·6, about the same as that of orbits already determined. Hence it appears that the orbits must be enormous, and the periods measured in thousands of years. W. W. B.

1555. *Peculiarity of θ Ursæ Majoris.* **C. Nordmann and Le Morvan.** (Comptes Rendus, 174. pp. 669–671, March 6, 1922.)—In continuation of work with the heterochrome photometer [see Abs. 814 (1922)] the authors find the distribution of intensity in the stars θ and ι Ursæ Majoris very nearly the same, though the former is classed F8 and the latter A5. A recent anomaly noted in 13 Cephei, which is also classed A5, was explained, on the hypothesis that its effective temperature was relatively low. In the present case, however, it cannot be suggested that ι Ursæ Majoris has a relatively low effective temperature, but the other star θ Ursæ Majoris must have an effective temperature relatively high for its class. The warning to be derived from this is that only in the mean does the effective temperature correspond closely with the spectral type, a single star being liable to show a very different value. W. W. B.

1556. *Spectroscopic Parallaxes with Objective-Prism Spectrograms.* **H. Shapley and B. Lindblad.** (Harvard Coll. Observat. Circ. No. 228. Nature, 109. p. 422, April 1, 1922.)—The authors find that large-scale spectrograms are not necessary, as had been supposed, and have obtained good results from the large stock of objective-prism spectrograms available at Harvard. The pair of lines most used are 4215 (ionised Sr) and 4326 (Fe). C N bands and lines of H, Ca, and Mn were also used. At present naked-eye stars K0 to K2 only have been investigated. A list of 50 parallaxes is given, including λ Sagitarii 0″·113 and δ Leporis 0″·091, the latter having a large proper motion of 0″·696. The probable error of a deduced absolute magnitude is of the order of 0·3 mag., which is satisfactorily small. W. W. B.

1557. *Relation of Spectral Type to Magnitude.* **H. Shapley and [Miss] A. J. Cannon.** (Harvard Coll. Obs. Circ. No. 226. Nature, 109. p. 281, March 2, 1922.—Abstract.)—225,000 stars are included in the Henry Draper catalogue of stellar spectra, which is now completed, but not fully published. More than 99 % of the stars fall into the six main groups of the Harvard system, B, A, F, G, K, and M. It is now known from the work of Lockyer and Russell that the order of evolution is from M to B for giants increasing in temperature and from B to M as they cool and become dwarfs. Thus there are two classes at each stage, and they differ more and more as M is approached. The tabulation in magnitude shows that for each magnitude A and K stars are prominent, the former showing a minimum and the latter a maximum importance about the 8th magnitude, while the G stars steadily increase in importance with lower magnitudes.

Spectral Division.	Visual Magnitudes Brighter than			
	6·25.	7·25.	8·25.	9·25.
B	719	1286	2061	3026
A	2018	5904	15,884	39,342
F	680	2160	6536	15,224
G	656	2456	8776	27,160
K	1984	6144	20,760	51,008
M	538	1453	4491	10,657

In the Harvard publication a plate shows graphically many features of this and other tables. W. W. B.

1558. *Parallax of Faint Companion of Capella.* **R. M. Tibbles.** (Astron. J. 34. p. 46, March 22, 1922.)—This is a 10·7 magnitude star near Capella, and sharing its proper motion; as pointed out by Furuhjelm in 1914 [see Abs. 831 (1914)]. Eighteen plates were obtained at Dearborn Observatory from 1914 September 27 to 1921 Feb. 24, and used to determine the parallax and proper motion. The results are: Relative parallax, 0″·055 ± 0″·010; proper motion in R.A., 0″·056

$\pm 0''\cdot 004$. These are rather smaller than those published by Daniel and Schlesinger, and by Lee and van Biesbroeck. W. W. B.

1559. *Masses and Densities of the Stars.* **F. H. Seares.** (Mount Wilson Observat., Contrib. No. 226. Astrophys. J. 55. pp. 165–237, April, 1922.)—*Mean Magnitudes and Masses of Visual Binaries and Dwarf Stars of the Different Spectral Types.*—A statistical comparison of the absolute magnitudes (M_b) of 105 visual binaries, the hypothetical magnitudes (M_c) of these and 400 other visual binaries (computed by Jackson and Furner, assuming the combined mass, $\mu = \mu_1 + \mu_2$, of each binary to be 2), and the absolute magnitudes (M_s) of 1152 single stars (including some binaries) by Kapteyn and Adams, gives the mean difference $(\bar{M}_b - \bar{M}_c) = (\bar{M}_s - \bar{M}_c) - 0\cdot 3 \pm 0\cdot 1$ for each type; that is, $\bar{M}_b = \bar{M}_s - 0\cdot 3 \pm 0\cdot 1$. This indicates that the selection used is sufficiently homogeneous, also that the variation of the mean magnitude of binary star components with spectral type is the same as that of single stars. The values of M_s for dwarf stars of types B0, A0, F0, G0, K0, and Ma are $-1\cdot 60 + 0\cdot 70$, $2\cdot 40$, $4\cdot 35$, $5\cdot 90$, and $9\cdot 80$ respectively. The geometric mean mass for each spectral type of visual binary was next computed from the formula $\log \mu = \log 2 - 0\cdot 6\,(\bar{M}_s - 0\cdot 3 - \bar{M}_c)$. The values of μ, slightly corrected for the effect of selection as determined by a study of the binaries of known parallax, give, when multiplied by $\frac{1}{2}$ to reduce to single stars, a first approximation to the geometric mean masses of single stars along the dwarf branch of Russell's diagram, the values for types B0, A0, F0, G0, K0, and Ma, coming out 10, 6·0, 2·5, 1·0, 0·68, and 0·59, respectively, in terms of the sun's mass. The data for visual binaries of known parallax indicate that the distribution of $\log \mu$ is approximately Gaussian and that the *dispersion in mass* is small, probably half the stars of each type having masses between 0·7 and 1·5 times the mean.

Mean Velocity and Energy of Dwarf Stars of Different Spectral Types.—The mean-square space-velocity corresponding to the mean magnitude was determined from the available data for each type, and these values were multiplied by the corresponding mean masses. The mean energy for each type so obtained is practically the same for all types from A0 to Ma, in spite of a 10 to 1 variation in mass. The logarithm of the *mean kinetic energy constant* is $3\cdot 27 \pm 0\cdot 036$ (average deviation per type) in terms of sun's mass and km./sec., corresponding to $3\cdot 5 \times 10^{46}$ ergs. The mean radial energy is also approximately constant for all except the B-type stars, which seem to be abnormal in this as in other respects. Whatever the cause may be, the distribution of energy among these stars seems to approximate to equipartition.

Masses of stars as functions of magnitude and spectral type were then computed from the values of the mean velocity for each magnitude and type, assuming the mean energy independent of magnitude as well as of type. Curves are given showing M as a function of type for various constant values of the mass. To get more reliable data for the giants, the masses of 28 Cepheids were computed from the period, magnitude, and surface brightness of each, using a formula based on the pulsation theory. If the masses computed in accordance with Eddington's theory of Cepheids are adopted, a further slight revision will be necessary. The constant mass lines would be less irregular if bolometric magnitudes were used instead of visual. For the Cepheids, the probable *dispersion in* *mass* for a given M and type is only about 20 %. This result taken with the data for visual binaries indicates that in general the luminosity of a star is very closely determined by its spectral type (temperature) and its mass.

Numerous other points are discussed, at too great length even in the author's abstract; for these the original paper should be consulted.

L. H. W.

1560. *Spectrophotometric Methods for Determining Stellar Luminosity.* **B. Lindblad.** (Mount Wilson Observat., Contrib. No. 228. Astrophys. J. 55. pp. 85–118, March, 1922.)—*Two Spectrophotometric Methods for Determining Absolute Magnitudes.*—(1) *Relative intensity of spectral regions on either side of* λ3907. Using the 10-in. Cooke refractor with 6° objective prism, a series of images of decreasing density was obtained for each star on each plate, making each exposure 0·707 times the preceding, and from these images the exposure ratio ($E = t_2/t_1$) required to give the same density in the two adjacent spectral regions was determined for stars in well-known groups with common proper motions, and hence common parallaxes—the Hyades, the Pleiades, the Ursa Major stream, and Præsepe—and also for some stars with known spectroscopic parallaxes, in all, 107 stars of types A and B and 74 stars of later types. The results show that, especially *for stars of type B8 to A3*, there is a definite correlation between E and M, the variation being such that even with the small dispersion here used the probable error of a determination of M for a star within this range of type and of absolute magnitude 0 to 4 is only 0·4 mag. (2) *Relative Intensity of Cyanogen Bands and Adjacent Spectral Regions.*—Using the same instrument and method as above, the relative density on either side of λ3889 was determined for 16 stars of known parallax, and (since the band at λ4216 though weak is more favourable for the redder stars) the relative density in regions λλ4144–4184 and λλ4227–4272 was determined for 78 late stars. The absorption was found to be strongest *for the giants of types* G5–K5 and much weaker for dwarfs; in fact all stars with $\log E > 0 \cdot 17$ are giants. Figures 3–5 show the variation of log E with M for various types.

Relation of Spectra of A and B Stars to Absolute Magnitude.—A study of some spectra made with the 60-in. showed that the increase in the density of the region λλ3889–3907 with reference to λλ3907–3935 is caused by a widening of the Hζ line and also of some arc lines of Fe and Si, which may be due to a greater density gradient in the outer layers of the less luminous stars of this type. α Cygni and the faint companion of 0_2 Eridani represent extreme types.

Spectral type and luminosity of 137 *faint stars of magnitudes* 10 *to* 14, in Messier 11, Messier 13, and Selected Areas 63 and 64, were determined from 10 plates made with a small focal-plane spectrograph attached to the 60-in. Dwarfs and giants were distinguished by applying the spectrophotometric results reported above.

Spectrophotometric Parallax Determinations.—The concordance of the results for log E as a function of M, as determined from the various groups of stars, indicates that the assumed parallaxes for the *Hyades, Pleiades, and Præsepe*, 0″·023, 0″·010, and 0″·0072, respectively, are accurate to within 10 %. The value found for *Messier* 11 is 0″·00025.

Schwarzschild's constant p for Seed 23 *plates* was determined for images made with the 10-in. refractor and 6° prism, and found to be equal to:

0·97–0·026 ($m-5$), where m is apparent magnitude ranging from 4 to 8. X-ray developer was used. [Erratum: *ibid.*, p. 413, June, 1922.] AUTHOR.

1561. *Upper Limit of Distance to which the Arrangement of Stars can be Determined.* **J. C. Kapteyn and P. J. Van Rhijn.** (Mount Wilson Observat., Contrib. No. 229. Astrophys. J. 55. pp. 242–271, April, 1922.)—If both $\phi(M)$ and N_m, the luminosity-curve and the total numbers of stars for each apparent magnitude were completely known, the star-density could be found for any distance from the sun. The paper deals with the question: What can be reached now that our knowledge of these quantities is limited? The conclusion is that the incompleteness of our knowledge of $\phi(M)$ is of little importance, but that the contrary is true for N_m. Even if we assume the law of the densities to hold for all values of m, the constants cannot be determined with the accuracy needed for the derivation of the densities at considerable distances. The limits of distance for which the density can be determined within 25 or 40 % of its amount were finally found on the supposition that the values of N_m are known to $m = 14$ and $m = 20$, respectively. With the limit $m = 17$, visual, for which we may expect complete values of N_m in the near future, the densities should become reliable for the whole of the domain within which the density exceeds 0·1 of that near the sun. AUTHOR.

1562. *Photographic Spectrum of the Aurora of May* 13–15, 1921. **Rayleigh.** (Roy. Soc., Proc. 101. pp. 114–123, May 1, 1922.)—A photographed spectrum of the aurora obtained on the night of March 14, 1922, shows the negative bands of nitrogen in considerable detail, also the green aurora line of unknown origin, which, however, is subordinate. A number of laboratory photographs of the negative bands of nitrogen excited in various ways are reproduced for comparison. With atomic ray excitation, and still better in the narrow positive column (capillary tube) at low pressure the development of the negative bands can be imitated. But other nitrogen spectra (line spectrum and second positive band spectrum) persistently appear in addition. The kathode-ray spectrum is free from these foreign spectra. But the negative bands produced in this way are not developed like those in the aurora, the intensity being much more concentrated in the first band of each group. Hard and soft kathode rays behave alike in this respect. The auroral spectrum is also discussed in relation to the upper atmosphere. Assuming that helium is the main constituent above 130 km., as the theory of diffusion indicates, then it is difficult, on the hypothesis of positive-ray excitation, to explain its absence from the spectrum of this particular aurora, which at Christiania reached to 470 km. Experiments on artificial mixtures indicate that helium should be visible. With kathode-ray excitation this difficulty would be lessened, but the different development of the nitrogen bands remains. It is possible that the true mode of excitation of the aurora has not yet been suggested. AUTHOR.

1563. *Calculation of Masses from Spectroscopic Parallaxes.* **H. N. Russell.** (Mount Wilson Observat. Contrib. No. 227. Astrophys. J. 55. pp. 238–241, April, 1922.)

LIGHT.

1564. *Shutter for Aerial Photography.* **A. Guillemet.** (Comptes Rendus, 174. pp. 806–809, March 20, 1922.)—Describes a new form of shutter for the production of an exposure of the order of 1/300 sec. over the whole plate (18 × 24 cm.) simultaneously. It consists of four concentric metal sector discs, of which two rotate in opposite directions at such a speed V that the required exposure is obtained. The other two discs rotate respectively at speeds V/6 and V/36, so that the objective is only uncovered at every 36 revolutions of the inner discs. In this way it is possible to obtain an exposure of 1/260 sec. every half second. A second part of the apparatus is described, for giving an exposure at regular intervals, or whenever desired. The light efficiency is 80 % for a focal length of 50 cm. J. W. T. W.

1565. *Light-Filter for Photographic Object-Glasses.* **H. Schulz.** (Zeits. wiss. Phot. 21. 9–12, pp. 232–239, April, 1922.) It is a familiar fact that, even with the best photographic objectives, there is a decrease of illumination towards the margin of the field which necessitates special treatment when the visual angle is of considerable magnitude. This variation in intensity is a particularly disturbing factor when, as in photographing landscapes with a wide expanse of sky, the distribution of illumination in the object is of such a nature as to accentuate the marginal diminution. The problem of the accurate reproduction of the distribution of light in a landscape has not yet been satisfactorily solved, although many devices have been tried. The filter devised by the author consists of a plano-convex and a plano-concave lens of the same glass with the same radius of curvature, so that the whole system, put together with a small intervening layer of air, acts as a plate parallel to the visual field, and therefore does not distort the image, assuming that the distance of the object is to be considered as infinitely great compared with the focal distance of the objective. The curved surfaces may be either spherical or cylindrical. Then follows a detailed description, with tables and mathematical demonstrations, of the results obtained with this new device, for which the author claims many advantages over those hitherto in use. E. F.

1566. *Modified Form of Double Slit Spectrophotometer.* **A. L. Narayan.** (Phil. Mag. 43. pp. 662–663, April, 1922.)

1567. *Stress-Optical Effect in Transparent Solids Strained beyond the Elastic Limit.* **L. N. G. Filon** and **H. T. Jessop.** (Roy. Soc., Phil. Trans. 223. pp. 89–125, July 14, 1922. Roy. Soc., Proc. 101. pp. 165–174, May 1, 1922.)—Describes experiments carried out on slabs of glass and on xylonite to determine whether the residual optical effect noticed on the removal of the load from a specimen which has been strained beyond the elastic limit is a true optical residual, or is simply due to the slow mechanical readjustment of stresses within the specimen. This would determine whether the stress or the strain is the immediate cause of the double refraction. In the case of glass under compression it was found that there was no trace of residual retardation on the removal of the load. Xylonite was tested under tension, and the application of the load was found to be followed by an immediate initial effect, roughly proportional to the load applied, followed by a creep. On unloading a similar immediate effect and subsequent creep were noticed. If the load be taken off after many hours, the effects at loading and at unloading are exactly similar. It was found that the strain followed the curve given by $s = s_0 + at^{1/3} + bt$, while the stress-optical effect followed a curve of the same form with different constants. The retardation plotted to simultaneous strain gave a straight line, whose constants, as well as those of the strain and the optical effect, varied from specimen to specimen, and on the same specimen with lapse of time. Hence it is important to use old and well-seasoned specimens in stress investigations. The relations can be accounted for on the theory that xylonite is made up of two constituents, one perfectly elastic and the other plastic, the stress-optical effect in each being strictly proportional to the applied stress, but the two components having different coefficients. It was found that these two components, if they exist, must be intimately mixed throughout the substance, as the removal of the surfaces from a specimen immediately before loading did not affect the results; these latter cannot, therefore, be due to the enclosure of a plastic core between elastic walls. J. W. T. W.

1568. *Scattering and Dispersion of Light.* **U. Doi.** (Phil. Mag. 43. pp. 829–834, May, 1922.)—In this paper the author derives Rayleigh's formula for the scattering coefficient of a gaseous medium by identifying the scattered energy with the energy of radiation itself from the electron which is set in motion by the incident light. This method gives possibly the simplest way of arriving at the result. [See Abs. 1070 (1920).] A. W.

1569. *Dispersion in Monoclinic Crystals.* **M. Berek.** (Zeits. f. Physik, 8. 5. pp. 298–304, 1922.)—Rubens [Abs. 569 (1920)] has found that monoclinic crystals exhibit dispersion of the optic axis of symmetry, this being particularly shown in the resonance region, where the refractive index undergoes large variations with the wave-length. Goens [Abs. 857 (1922)] has investigated this anomalous dispersion in the infra-red region. The present mathematical paper is concerned more particularly with dispersion in the visible region of the spectrum, and it is shown that, in general, dispersion of the optic axis of symmetry is particularly strong when the dispersion of double refraction is largest. A. W.

1570. *Interferometer Method of Measuring the Phase Difference at Metallic Reflection.* **H. P. Waran.** (Phil. Mag. 43. pp. 471–477, March, 1922.)—During the experiments on the use of a thin layer of transparent liquid floated on mercury acting as a parallel-plate interferometer, it was suspected that the difference in the conditions under which reflection takes place at the two surfaces might be a disadvantage. To test this a Lummer plate was silvered along one half in the direction of the length. The number of the interference bands was doubled, due to the phase difference introduced at metallic reflection. One set of bands was obtained with light polarised in the plane of incidence, while another set was obtained with light polarised perpendicularly to this plane. Unpolarised light gave the two sets simultaneously. A similar appearance was obtained when one half of the plate, instead of being silvered, was in contact with a mercury surface. The theory of the phenomenon is developed in the paper, and it is concluded that this may be made an accurate method for the determination of the phase difference introduced at metallic reflections, and that the measurements give results more accurate than those obtainable by the methods where surface impurities introduce errors tending to lower the values obtained. J. W. T. W.

1571. *Dispersion Formulæ and the Polarisation of Scattered Light. Application to Hydrogen.* **T. H. Havelock.** (Roy. Soc., Proc. 101. pp. 154–164, May 1, 1922.)—The object of this paper is to connect the polarisation of light scattered by a simple homogeneous medium with the constants of the dispersion formula for that medium. The result of the calculation gives the ratio of the intensities of the two polarised components for all wave-lengths for which the dispersion formula is valid. The calculated values are in substantial agreement with the revised experimental value 0·0383 obtained by Rayleigh for hydrogen. [See Abs. 671, 1559, and 1677 (1921).] A. W.

1572. *Atmospheric Pressure and Refractive Indices: Indices for Optical Glass.* **J. W. Gifford.** (Roy. Soc., Proc. 100. pp. 621–626, March 1, 1922.)—Shows that the change of refractive index of air due to barometric pressure is not negligible in the fifth place of decimals, and illustrates by means of an example the method of reducing refractive indices of glass, etc., to standard conditions of temperature and pressure. A table gives the values of indices for seven types of optical glass recalculated on this basis. A note is added on the effect of errors of the goniometer circle on the accuracy of the method of measurement employed.
J. W. T. W.

1573. *Improvement of Visibility of Distant Objects.* **H. Bénard.** (Nature, 109. pp. 412–413, April 1, 1922.)—With reference to recent notes on this subject by Raman [Abs. 308 (1922)] and by Lowndes and Wilson-Barker (*ibid.*, Nov. 10, 1921) the author points out that two years ago he published a complete essay, which considered in detail all the points mentioned in the papers referred to above. The results were communicated to the British Board of Invention and Research (1917). At the end of the war the French Navy had a small number of binoculars equipped with spar polarisers of the Glazebrook-Ahrens type cemented with a special oil. A few of these binoculars were supplied to the British Government. A. W.

1574. *Convection of Light (Fizeau Effect) in Moving Gases.* **C. V. Raman and N. K. Sethi.** (Phil. Mag. 43. pp. 447–455, March, 1922.)—The second part of Fresnel's theory, that the ether inside a moving body drifts along with a diminished velocity, was tested in water by Fizeau, and more carefully by Michelson and Morley. The good agreement with theory was discounted by Lorentz's electron theory, and Zeeman further experimented, applying the corrections required by Lorentz. The present authors are concerned with the extension of this to gases, accepting previous work as demonstrating it for solids and liquids. The intention was to have air sucked steadily through long tubes with a constant velocity of 50 m. per sec., and the arrangements made are given in detail. The direction of the current could be reversed so that a double effect should be observed, and precautions were taken to ensure the parallelism of the beams of light, and the steadiness of flow which was at first very uneven. The engine employed failed to produce a current of more than 20 m. per sec., and the work could not generally be done in the daytime on account of temperature changes, but under favourable conditions a shift of about one-twentieth of a fringe was observed in the direction required by theory. Unfortunately the fringes showed a distinct rotation when the air-current was reversed, on subsequent attempts to repeat the experiment, and the work was interrupted. With a more powerful "blower" a good prospect of success is promised for the time when a resumption is possible. W. W. B.

1575. *New Optical Property of Biaxial Crystals.* **C. V. Raman** and **V. S. Tamma.** (Phil. Mag. 43. pp. 510–513, March, 1922.)—The paper describes a new optical effect observed with a biaxial crystalline plate, viz., that such a plate though bounded by parallel faces, is capable of forming on one side of it when suitably oriented, a *real* erect image of a source of light such as a luminous filament placed at some distance from it on the other side. L. H. W.

1576. *Deformation of the "Rings and Brushes" as Observed through a Spath Hemitrope.* **B. N. Chuckerbutti.** (Phil. Mag. 43. pp. 560–567, March, 1922.)—On examining a twinned crystal of Iceland spar with convergent plane-polarised light and between crossed nicols, the ordinary rings and brushes are found to be distorted, the amount and nature of the distortion changing with the orientation of the crystal. In some cases the distortion resembles more or less that produced by the superposition of a quarter-wave mica plate upon a crystal of Iceland spar cut perpendicular to the axis, the plane containing the optic axes of the mica plate making an angle of 45° with the vibration planes of the crossed nicols. A mathematical treatment is given of the problem of two similar crystal wedges separated by a thin twinned lamina. A. W.

1577. *Diffraction by Molecular Clusters and the Quantum Structure of Light.* **C. V. Raman.** (Nature, 109. pp. 444–445, April 8, 1922.)—According to the Einstein-Smoluchowski formula for the scattering power of a fluid, the intensity of the diffracted beam should be proportional to the compressibility β of the fluid, and should thus be very large near the critical temperature since the compressibility there is great. Experiments by Keesom and Onnes have confirmed this result in the case of ethylene vapour over a range of temperature of a few degrees above the critical temperature. The scattering powers of liquid CO_2 and vapour for a considerable range of temperatures below the critical point have recently been determined in the author's laboratory by K. R. Ramanathan, who has found that the formula is approximately valid only for a range of a few degrees below the critical temperature, and then the scattering falls off much more rapidly than would be expected from the formula. These results are significant in view of Rayleigh's observation that the scattering power of saturated CO_2 vapour at 21° C. is only 102 times that of the gas at atmospheric pressure whereas according to the formula it should have been 855 times as great. The failure of the formula indicated here is surprising in view of its successes in other directions. Einstein's theory is based on the idea that the fluctuations of density and the resulting scattering of light are due to *mass-clustering*. If, however, we assume that it is *molecular-clustering* that is of importance it is easy to explain the increased scattering near the critical point, and the rapid fall at lower temperatures. But the difficulty remains, why the *mass-clustering* considered by Einstein does not, as it should according to the classical wave-theory of light, give rise to an increased scattering of light. It may be necessary to adopt the quantum theory of the structure of light as propagated in space (and not only when it is absorbed or emitted) in order to explain the facts of molecular diffraction. Further work now in progress may help to clear up this question. [See Abs. 1339 (1922).] A. W.

1578. *Molecular Scattering of Light in Water and the Colour of the Sea.* **C. V. Raman.** (Roy. Soc., Proc. 101. pp. 64–80, April 1, 1922.)—This paper puts forward a new theory of the colour of the sea, namely, that it is due to the molecular scattering of light in water. The intensity of molecular scattering in water can be calculated from the "theory of fluctuations" developed by Einstein and Smoluchowski and is found to be about 160 times that in dust-free air. This agrees with the value observed experimentally. The coefficient of extinction of light in water calculated from theory also agrees with the observed value in the parts of the spectrum in which there is no selective absorption. A sufficiently deep layer of pure water exhibits by molecular scattering a deep blue colour more saturated than sky-light and of comparable intensity. The colour is primarily due to diffraction, the absorption only making it of a fuller hue. The theories hitherto advanced that the dark blue of the deep sea is reflected sky-light, or that it is due to suspended matter, are discussed, and the conclusion is drawn that these theories are erroneous. A number of effects observed at sea, due to polarisation and multiple scattering, are described and explained. [See Abs. 1339 (1922)].
A. W.

1579. *Interference Phenomena Due to the Introduction of Sodium Vapour into One of the Paths of the Fizeau-Michelson Interferometer.* **G. C. Dibbetz, Jr.,** and **P. Zeeman.** (K. Akad. Amsterdam, Proc. 24. 6 and 7. pp. 206–208, 1922.)—When Na vapour is introduced into one of the paths of light of the interference arrangement used in Fizeau's experiment, remarkable shifts of interference fringes may be observed. It is necessary for the Na vapour to act as a prism. This is secured by introducing sodium into an iron tube with glass end-plates and connected to an air-pump; the tube is heated at the bottom and cooled at the top, so that the required density distribution is secured. The interference fringes are projected on the slit of a spectroscope so that the change of the distance of the interference fringes with wave-length can be followed, the general arrangement being similar to that used in previous work on Fresnel's convection coefficient for light of different colours in water [Abs. 682 (1915)]. Photographs of the effects obtained are reproduced. A. W.

1580. *Possible Relationship between the Focal Length of Microscope Objectives and the Number of Fringes Seen in Convergent Polarised Light.* **F. I. G. Rawlins.** (Phil. Mag. 43. pp. 766–767, April, 1922.)—Groth has made a statement to the effect that the number of interference fringes

seen in crystals by means of a microscope in convergent polarised light is a function of the focal length of the objectives used. Experiments were undertaken with crystals of quartz, tourmaline, and mica, the approximate thicknesses being respectively 5, 4, and 1 mm. The objectives used were ordinary achromatics, and the figures were viewed by means of a supplementary Becké lens above the eyepiece. Daylight was used with a red gelatine filter. With the quartz crystal as the focal length F of the objective used was decreased in steps from 32 mm. to 4 mm. the number N of rings observed increased from 0 to 11. The results for tourmaline and mica were similar. By plotting $\log_e F$ against N it was found that straight lines were obtained in all three cases, so that the relation between F and N is of the form $F = F_0 e^{-AN}$, where A is a constant. The values found for A were; quartz, 0·213; tourmaline, 0·105; mica, 0·249.
A. W.

o **1581.** *Graphical Method of Treating Fresnel's Formulæ for Reflection in Transparent Media.* **C. H. Lees.** (Phys. Soc., Proc. 34. pp. 114–117; Disc., 117–119, April, 1922.)

1582. *Brilliance and Chroma in Relation to Zone Theories of Vision.* **L. T. Troland.** (Optical Soc. America, J. 6. pp. 3–26, Jan., 1922.)

1583. *Some Problems of the Mass-Spectrograph.* **F. W. Aston** and **R. H. Fowler.** (Phil. Mag. 43. pp. 514–528, March, 1922.)

1584. *Action of Light on Silver Bromide.* **E. J. Hartung.** (Chem. Soc., J. 121. pp. 682–691, April, 1922.)—Investigation of the action of light on silver haloids by means of the microbalance shows that thin films of the chloride, bromide, and iodide of silver lose weight when exposed in air to sunlight. This phenomenon is due to loss of halogen, and the original weight is almost completely restored by rehalogenation. The decomposition is greatly accelerated in a vacuum, but the effect of moisture is small and the presence of oxidising agents is not essential to the change, although ozone exerts an accelerating action. These results disprove the oxybromide theory of the darkening of silver bromide, and also the theory which supposes a sub-bromide to be formed. From evidence of a quite different character, Lüppo-Cramer and others have advanced the view that the action of light on silver haloids results in partial decomposition into metal and halogen, the metal forming solid solutions with the undecomposed haloid and so being almost insoluble in nitric acid. The results of the experiments here recorded support this view, although, if solid solutions are formed, as appears probable, they are so rich in silver after prolonged exposure of thin films in a vacuum that the metal dissolves readily in nitric acid.
T. H. P.

1585. *Relation between Sensitiveness and Size of Grain in Photographic Emulsions.* II. **T. Svedberg.** (Phot. J. 62. pp. 186–192; Disc., 192–196, April, 1922.)—In a previous paper [Abs. 646 (1921)] the author has shown that in a certain emulsion not all the grains of a certain size are made developable by a certain exposure, and that there is a distinct relation between the percentage number of grains made developable after a certain exposure and their size; the percentage number increases approximately exponentially as the cross-section of the grains increases.

These rules are claimed to hold good only for grains formed under very nearly the same conditions such as grains within one and the same emulsion. There are reasons to believe that there can exist silver bromide emulsions built up of grains of equal size and shape but with different sensitiveness, and vice versa. In the present paper an explanation is offered of the behaviour of the grains in this respect by means of a simple hypothesis, and some experimental evidence for the validity of the theory is given. It is assumed that the product of the light action in the halide grain, i.e. the substance of the latent image, consists of small centres distributed through the grain, or through the light-affected part of the grain, according to the laws of chance. The small and the larger grains in one and the same emulsion are built up of the same kind of light-sensitive material, just as if they were fragments of different size from one homogeneous silver bromide crystal. According to the theory given, the reduction of the grain proceeds out from the developable centres. It is found that the average number of centres originating from a single halide grain is small. All the developable centres corresponding to infinite development have not been made accessible to measurement owing to the fact that some centres require so long a time to be made visible that the other centres have by then already grown together to an inextricable network of silver. Because of their tendency to grow together it is impossible to study the high exposures. In those cases the average number of centres is so great that it will often happen that two or more centres are too closely situated to be distinguished as separate points. The most urgent measurements to be carried out in connection with the number and distribution of the centres thus made visible are, to ascertain whether within a class of equal-sized grains the centres are distributed according to the laws of chance, and then to find if, in one and the same emulsion, there is a certain relation between the average number of centres per grain and the size of the grains. There is also the question whether the average number of centres in grains of equal size is different in emulsions of different origin, and the very important question of the relation between exposure and the number of centres made developable. Experiments are described which were carried out to answer the two first questions. The results obtained show that there can be little doubt that the centres are really distributed according to the laws of chance. It also appears that the average number of developable centres increases rapidly with increasing size of the grains. The apparent difference between the action of X-rays and light is also considered, as is also the deviation from the exponential curve in the domain of under-exposure. **A. E. G.**

1586. ***Reducibility of the Individual Halide Grains in a Photographic Emulsion.*** **T. Svedberg.** (Phot. J. 62. pp. 183–186; Disc., 186, April, 1922.)—The author has previously [Abs. 646 (1921) and Abs. 868 (1922)] pointed out that the opinions of investigators regarding the way in which the individual halide grains are reduced when developed have been widely divergent. It seems, however, that of late the evidence in favour of the view that the halide grain may be looked upon as either completely reducible or not reducible at all is accumulating. Slade and Higson, and Volmers are quoted as in favour of this opinion. Renwick has expressed the suspicion "that some grains may be incompletely developed and, after clearing of silver, leave residues which would be reckoned as insensitive grains of small size instead of as larger and light-affected grains."

It is of importance to decide whether this possible source of error is real or not. The main difficulty is that the silver-halide grain must be photomicrographed before development and without being light-affected by exposure to the intense light necessary for illuminating the grain. Two methods of accomplishing this object are described, as are also the method of development employed and the experimental details. It is found that the percentage of developable grains is not greater when the grains are closely packed together, and that there is no perceptible change in the size of the undeveloped grains. On the spots where 181 developed grains had been, there remained after clearing away the silver, no traces in 179 cases; only in 2 cases were parts of incompletely reduced grains to be seen. It is also observed that even over such a small distance as 1 μ no noticeable transport of silver ions takes place from the unaffected to the developable grains. Some preliminary experiments with a metol-hydroquinone developer gave analogous figures to those here given both on de-sensitised and not de-sensitised grains. It is therefore concluded that the results are of a general character, although it is admitted that there may be cases where the course of the reduction of the silver-halide grain is somewhat different from that found here. A. E. G.

1587. *Svedberg's Method of Grain Analysis of a Photographic Emulsion.* **S. E. Sheppard** and **A. P. H. Trivelli.** (Eastman Kodak Co.'s Research Lab. Comm. No. 137. Phot. J. 62. pp. 196–197, April, 1922.)—Renwick has made certain very pertinent criticisms in regard to "fog" production on dissolving and diluting the emulsion, and again in regard to the possibility of incomplete development of certain grains. The present investigation shows that the "fog" danger is slight, provided that the exposure to the dark-room light be reduced to a minimum, and that maintenance of increased temperature for the diluted emulsion be made as brief as possible. The possibility that some grains may be incompletely developed and, after clearing of silver, leave residues which would be reckoned as insensitive grains of small size, is checked as follows: Although the traces of the dissolved grains are not easily visible, they can be photographed, using a Wratten H filter. The "ghosts" of the dissolved silver grains (using a chromic acid de-silvering solution) consists of a mixture of silver chromate and CrO_2, which is not very opaque visually but can be photographed. This makes it quite easy to see if any residues are left; none is found with the development used. Another possible source of error, not noticed before, is the eroding action of sodium sulphite in alkaline developers on the undeveloped grains. The amount of this is not usually large, and can generally be allowed for. The conclusion arrived at is that with due precautions to meet the possible sources of error the Svedberg procedure provides a valuable and reliable method of optical analysis. A. E. G.

1588. *Automatic Method of Kinematograph Film Processing.* **H. V. Lawley.** (Phot. J. 62. pp. 146–151; Disc., 151–152, March, 1922.)—The word automatic, as used here, refers to the actual mechanical feeding of the film through a succession of baths, as distinct from doing it by hand. Practically the methods in use to-day are the same as those first adopted, except that skeleton frames on which the films are wound are used instead of a drawing board, and upright developing tanks instead of dishes. The methods of development with those machines which are

entirely automatic and admit of little or no control whatever in development are first described, then diagrams and details of the new method are given. By this method the film is continuously developed, fixed, dried, and so forth, by means of long parallel vertical tubes, each 2¼ in. in diameter. The film passes over a series of sprockets which are turned at an even rate by means of a shaft worked by a small motor, and then passes into these long tubes down and up in succession, travelling at the rate of 1650 ft. per hour. The two developing tubes are each 26 ft. in length. The passage of the film in each tank occupies 2 minutes. The film enters the first tube dry, and comes out wet, and enters the second tube wet and comes out wet, and the absorption of developer is 4 times greater in the first tube than in the second. There is a drip feed from the developing tank to each tube entirely under the control of the operator, and so regulated that the amount of developer which the film absorbs is automatically replaced. The developer is kept in constant circulation by the film itself as it passes down and up the tubes, so that the fresh developer coming in is evenly distributed. The normal time of development is 3 to 3½ mins., and by an arrangement involving the use of a counter-weight development can be controlled on any section so as to give more or less development at will. The film is judged foot by foot as it passes out of the developer, and if after 10 or 15 ft. have passed it is decided that a slight error has been made on the light side, the film can be halted and the degree of development made exactly right. The only part of the film about which there could be any doubt would be the first 50 ft. Another great advantage of this method appears to be the possibility of manipulating great lengths of film without a join.
A. E. G.

1589. *Neutral Wedges in Photographic Sensitometry.* **E. Lehmann.** (Zeits. wiss. Phot. 21. 9–12. pp. 214–220, April, 1922.)—Describes measurements made on the uniformity and the constancy of absorption throughout the photographic spectrum for neutral wedges used in sensitometry. It was found that in the case of lamp-black suspensions in gelatine, too coarse a powder gave an uneven absorption, while too fine a powder, owing to partial solution, gave a departure from strict neutrality. The most satisfactory results were obtained with silver grain obtained by dissolving the film from a grey developed dry-plate, using a hydroxylamine developer.
J. W. T. W.

1590. *New Possible Uses of Densitometers.* **H. Naumann.** (Zeits. wiss. Phot. 21. pp. 113–116, Feb., and 21. 7–8. pp. 186–192, April, 1922.)—In the first paper the densitomer is described in detail and illustrated diagrammatically. The remainder of the matter in both papers consists almost entirely of a discussion of the preparation of filters for use under various lighting conditions.
A. E. G.

1591. *Darkening of Silver Bromide Grains on Exposure as Evidence of their Heterogeneity in Emulsions.* **J. Brooksbank.** (Phot. J. 61. pp. 421–424; Disc., 424–425, Dec., 1921.)

1592. *Optical Rotatory Dispersion.* II. *Tartaric Acid and the Tartrates.* **T. M. Lowry** and **P. C. Austin.** (Roy. Soc., Phil. Trans. 222. pp. 249–308, April 11, 1922. Bakerian Lecture.)—(1) The rotatory power of tartaric acid for a series of 9 wave-lengths has been determined in aqueous solutions of 11 different concentrations ranging from 5 to 55 % by weight, and also for 21 and 26 wave-lengths respectively at two other concentrations. (2) The optical rotatory power of tartaric acid, like that of its methyl and ethyl esters, is expressed to a close degree of approximation by the formula $\alpha = k_1/(\lambda^2 - \lambda_1^2) - k_2/(\lambda^2 - \lambda_2^2)$. (3) The rotatory power of sodium tartrate agrees very closely with Biot's law, $\alpha = k/\lambda^2$, but required for its exact expression a two-term formula similar to that used for tartaric acid. Potassium and ammonium tartrates and Rochelle salt give similar dispersion curves, but deviate more widely from Biot's law. L. H. W.

1593. *The Contrast Rating of Gaslight and Bromide Papers.* **B. T. J. Glover.** (Phot. J. 62. pp. 132–138; Disc., 138–141, March, 1922.)

1594. *Absorption Spectrum of Didymium Glasses.* **F. Weidert.** (Zeits. wiss. Phot. 21. 9 and 12. pp. 254–264, April, 1922.)—Describes the results of measurements on the absorption spectra of glasses containing various proportions of oxides of the didymium group, and of water solutions of the same salts. The apparatus used, and the method of experiment are described in detail. The bands in the glasses are broader and less sharp than in the water solutions. Two groups of absorption bands can be distinguished, namely, one which is unchanged in position and general characteristics whatever the concentration, and another in which the components are altered by change in concentration. The paper includes a number of spectrographs of various glasses and solutions in different thicknesses and concentrations. J. W. T. W.

1595. *Spectrum of Hydrogen.* **T. R. Merton and S. Barratt.** (Roy. Soc., Phil. Trans. 222. pp. 369–400, April 27, 1922. Bakerian Lecture.)—(1) A discussion is given of the conditions under which the Balmer series and the secondary spectrum of hydrogen are produced. (2) The wave-lengths of about 1200 lines in the secondary spectrum have been measured. (3) It has been found possible to classify the lines into different physically related groups under different conditions depending on the pressure of the gas in the discharge tube, the electrical conditions of excitation, and the presence of helium. (4) These methods of classifying the lines have been compared with the results obtained by other investigators relating to the Stark and Zeeman effects, and with the regularities observed by Fulcher. (5) A comparison has been made of the wave-lengths of lines of different classes in the secondary spectrum with the Fraunhofer and sun-spot spectrum. No evidence of the presence of the secondary hydrogen in the sun has been obtained.

(6) *A new method of measuring the widths of spectrum lines* has been developed. (7) It has been shown that the secondary spectrum is due to the hydrogen molecule. (8) Experiments have been made which appear to show that when electrical discharges are passed through vacuum tubes, a partial separation of the gases takes place, and this appears to afford a satisfactory explanation of a number of phenomena which have been observed. (9) A number of observations relating to the appearance of impurity lines in vacuum tubes are discussed. AUTHORS.

1596. *Absorption Spectrum of Benzene Vapour and Fundamental Magnitudes of the Benzene Molecule.* **V. Henri.** (Comptes Rendus,

174. pp. 809–812, March 20, 1922. J. de Physique et le Radium, 3. pp. 181–211, June, 1922.)—The ultra-violet absorption spectrum of benzene vapour may be represented very exactly by the formula, $1/\lambda = A - B + (an + a'n^2 + \ldots) - (bp + b'p^2 + \ldots) + \alpha(m^2 - q^2)$ n, p, m, q being the whole members 0, 1, 2 . . . ; in virtue of Bohr's principle of correspondence, $q = m$ or $q = m \pm 1$. The spectrum is composed of four series of superposed bands obeying the following formulæ:

$$\begin{aligned}
&\text{(I)}\ 1/\lambda = 37703 + 921{\cdot}4n - (159p + 2p^2) + 2(m^2 - q^2),\\
&\text{(II)}\ 1/\lambda = 37494 + 921{\cdot}4n - (159p + 2p^2) + 2(m^2 - q^2),\\
&\text{(III)}\ 1/\lambda = 37613 + 921{\cdot}4n - (159p + 2p^2) + 2(m^2 - q^2),\\
&\text{(IV)}\ 1/\lambda = 37426 + 921{\cdot}4n - (166p + 2(m^2 - q^2),
\end{aligned}$$

where $n = 0, 1, 2, 3, 4, 5, 6, 7$; $p = 0, 1, 2, 3, 4, 5, 6$; $q = m$ or $m \pm 1$ and $m = 1, 2, \ldots 10$. With the eight values of n correspond eight groups of bands, the most intense of these having the wave-lengths: A = 2667, B = 2589, C = 2528·5, D = 2471, E = 2415·9, F = 2363·5, G = 2324·4, H = 2275·2, and with these eight groups of bands correspond the eight bands of liquid or dissolved benzene. The positions of the heads of the bands in each group correspond with the different values of p, and the values of m give the fine structure of each band; the intensity of the bands diminishes very rapidly as p increases. The constants $a = 921{\cdot}4$ and $b = 159$ represent the numbers of vibrations of the atomic nuclei or groups of atoms in the molecule, so that the infra-red absorption spectrum of benzene should be expressed by the formula, $1/\lambda = an - bp = 921{\cdot}4n - 159p$, which accords well with the results of experimental investigations. The fine structure of the bands which results from the rotation of the molecules gives for all the series $\alpha = 2 = h/(8\pi^2 gc)$, the moment of inertia g for the benzene molecule being $1{\cdot}45 \times 10^{-38}$. Benzene crystallises in the rhombohedral system in bipyramids, the axial ratios being 0·89 : 1 : 0·80, and it may be assumed that the molecule has the form of a bipyramid differing little from an octahedron, the six carbon atoms occupying the angles. Calculation from the moment of inertia gives for the distance between the carbon atoms, $1{\cdot}85 \times 10^{-8}$ cm. and for the diam. of the molecule, $2{\cdot}6 \times 10^{-8}$ cm.; the viscosity of benzene vapour leads to the value $3{\cdot}2 \times 10^{-8}$ cm. for the diam. of the molecule, and the distance between the carbon atoms is $1{\cdot}54 \times 10^{-8}$ in diamond and $1{\cdot}75 \times 10^{-8}$ in graphite. These results show that the benzene molecule is a highly symmetrical structure having movements obeying the simple laws deduced for diatomic molecules. The molecule appears to consist of two halves, $C_3H_3 - C_3H_3$, each half vibrating in respect to the other. This hypothesis is supported by the fact that negatively-charged groups C_3H_3 are obtained when benzene is introduced into a positive-ray tube. T. H. P.

1597. *Ultra-Violet Absorption Spectrum of Phenol in Different Solvents.* **F. W. Klingstedt.** (Comptes Rendus, 174. pp. 812–815, March 20, 1922.)—The absorption spectrum of phenol dissolved in pentane or hexane, which the author terms the normal spectrum, comprises two regions in the ultra-violet: the first, between λ = 2860 and 2400 Å., contains three intense narrow bands, and the second, between λ = 2325 and the extreme ultra-violet, two wide bands. This spectrum is derived from that of phenol vapour by broadening and fusion of the bands, with displacement towards the red. The absorption spectrum of phenol in solution varies with the nature of the solvent, and in this respect solvents may be divided into two groups: (1) those, such as CCl_4, chloroform, ether, etc., which do not modify the general aspect of the spectrum, but produce only displacement and broadening of the bands; (2) those, including methyl and ethyl alcohols, water, etc., which alter completely the spectrum of the phenol, this exhibiting only one very broad, uniform band. The absorption spectrum of pure liquid and solid phenol occupies a position intermediate to these two types. T. H. P.

1598. *Spectrum of Beryllium Fluoride.* **S. Datta.** (Roy. Soc., Proc. 101. pp. 187–194, May 1, 1922.)—A continuation of previous work [Abs. 1911 (1921)]. The spectrum of beryllium fluoride, hitherto unrecorded, was investigated with the object of ascertaining whether the relations previously found for Mg, Ca, Sr, and Ba are maintained in the case of beryllium. The spectrum of BeF_2 has been found to consist of six groups of bands, all in the ultra-violet between λ2800 and λ3400, and all fading off towards the red. The strongest band at λ3009 has been investigated in detail, and found to include three series of lines, which depart considerably from the usual type of formula. The groups of bands have been found to be similar to one of the groups of MgF_2, and are related to this group in accordance with the formula for alkaline earth fluorides given previously. A. W.

1599. *Vacuum Spark Spectrum of Silicon.* **R. A. Sawyer** and **R. F. Paton.** (Phys. Rev. 19. pp. 256–257, March, 1922.)—In the case of the spark between silicon electrodes in air satisfactory spectra are difficult to obtain owing to the rapid oxidation of the electrodes. Good results have now been obtained by producing the spark in a highly exhausted brass box and photographing the spectrum through a window. The present paper gives intensities and wave-lengths of 55 lines thus obtained, the wave-lengths ranging from λ4085 to λ6372. The iron arc was used for comparison, and the probable error is about 0·1 Å. from λ4100 to λ5200, and about 0·3 Å. from λ5600 to λ6400. Among the lines several groups of pairs with constant frequency difference have been noticed. Six pairs have a frequency difference of about 61·4, five pairs a difference of about 17·2 and four other pairs a difference of about 34·2. A. W.

1600. *Regularities in Band Systems.* **A. Kratzer.** (Ann. d. Physik, 67. 2. pp. 127–153, April 27, 1922. Habilitationschrift, Munich.)—A discussion is first given from the point of view of the quantum theory as applied to the anharmonic oscillator, of the theoretical basis of Heurlinger's formula [Abs. 1071 (1920)] for the null-line of band series. The formula is then applied to the oxygen bands and to the violet cyanogen bands. Assuming anharmonic oscillations of the nucleus, it is shown how the constants in Deslandres' band series formula depend on the oscillation quanta, and the theory is tested by experimental data. By means of this dependence a theoretical explanation is given of the whole system of the cyanogen bands, and a theoretical formula with 9 constants is given for the lines of the violet cyanogen band system. [See Abs. 861 (1921).] A. W.

1601. *Grating Space of Mica and the Intensities of the Spectral Orders.* **B. Davis** and **H. M. Terrill.** (Nat. Acad. Sci., Proc. 8. pp. 59–60, April, 1922.)—Measurements were made by an ionisation spectrometer the standards of wave-length being the $K_{\alpha_1}(\lambda = 0\cdot710)$ and the $K_{\beta_1}(\lambda = 0\cdot633)$ emitted from a Coolidge tube having a molybdenum target. The results are presented in tabular form. The relative intensities of the α_1 and β_1 lines are given, and it is seen that the odd orders are stronger than the even orders, as observed by de Broglie. The third and fifth orders are stronger than the first. Radiation at higher orders than the seventh was observable. The values obtained for the grating space d calculated for the two lines agree fairly well with Siegbahn's calculations from Gorton's measurements. A. W.

1602. *Fine Structure of the Balmer Series.* **O. Oldenberg.** (Ann. d. Physik, 67. 1. pp. 69–72, April 12, 1922.)—McLennan and Lowe [Abs. 889 (1922)] have published results on the fine structure of the Balmer series, which appeared to disagree with Sommerfeld's theory. The doublet separations found showed a decrease from H_α to H_δ. Several possible sources of error are here pointed out, and it is concluded that McLennan and Lowe's results are not necessarily opposed to Sommerfeld's theory. McLennan and Lowe also found that under certain conditions the first four members of the Balmer series appeared as triplets. Experiments carried out by Oldenberg with a high-dispersion prism spectroscope combined with an echelon failed to show any trace of a third component of H_α in pure hydrogen, but with nitrogen present a triplet was found, the new component of which was traced to the nitrogen present. It appears probable that the triplet appearances found by McLennan and Lowe are due to nitrogen band lines. A careful repetition of the work of McLennan and Lowe seems to be desirable. A. W.

1603. *Occurrence of Spark Lines (Enhanced Lines) in the Arc.* II. **G. A. Hemsalech** and **A. de Gramont.** (Phil. Mag. 43. pp. 834–871, May, 1922.)—The spectra of lead and tin have been dealt with in a previous paper [Abs. 1295 (1922)]. The present paper is concerned with Mg, Zn, and Cd. The experiments described, together with those on lead and tin, go to show that the emission of light radiations in an electric arc is governed by a number of factors which generally act simultaneously, and thereby complicate the task of tracing the origin of any particular spectrum lines. By means of new experimental methods it has been found possible to bring out distinctly the effects of that factor which is more directly responsible for the emission of spark lines, the excitation of which appears to be connected with the existence of strong electric fields. The emission of spark lines during the first phase of a liquid film arc was found to be independent of the nature of the liquid used. Raising the voltage of the arcing current prolongs the life of the spark lines in the second stage, and in the case of magnesium brings into prominence the lines of the Rydberg series. The behaviour of the Mg line λ4481 is remarkable. The emission of this line either falls off quite suddenly in intensity or stops abruptly at a definite point during the second phase. This critical point corresponds to an applied electric field of approximately 500 volts/cm. In the case of Cd the interesting fact was discovered that during the gradual decline of the acting electric forces the character of the spectrum of the 3rd and 4th type enhanced lines changes abruptly at several definite stages, as though the radiating centres concerned were at these points undergoing sudden modifications in their structure. A stable arc obtained between Mg poles in an atmosphere of nitrogen showed λ4481 as a sharply defined line, and the Rydberg series was also prominent. Experiments are described which seem to indicate that the broadening of the hydrogen lines H_α and H_β observed during the early stages of an arc flash is caused by the strong electric field set up momentarily when the electrodes separate. Direct calculation of the field intensity has given a value in good agreement with that determined from the displacement of the outer components of H_β in the first phase of a water arc. A. W.

1604. *Excitation of the Enhanced Spectra of Sodium and Potassium in a Low-Voltage Arc.* **P. D. Foote, W. F. Meggers,** and **F. L. Mohler.** (Astrophys. J. 55. pp. 145–161, April, 1922.)—*Variation of the Spectra of Na and K with Energy of Electronic Impact.—The quantum theory* leads to the conclusions: that all the arc lines are emitted by neutral atoms and should be excited at voltages above the ionisation voltages, 5·1 for Na and 4·3 for K, and that the enhanced lines are emitted by singly ionised atoms and, in the case of the alkalies, should be excited when (*b*) the valence electron is knocked out of its orbit, after (*a*) an electron from the outer ring (*L*-ring for Na, *M*-ring for K) has been removed. In the case of Na, the ionisation (*a*) requires 35 volts if it is complete, giving *La*-radiation, or 30 volts if the electron goes to the L_α orbit; and since the displacement (*b*) requires a maximum of 14 volts, the enhanced spectrum for Na should be excited by two successive impacts at 35 volts and possibly at 30 volts, and the highest frequency should correspond to about 14 volts. The corresponding figures for K are: 23 volts for the excitation of the *Ma*-radiation, possibly 20 volts for M_α and the enhanced spectrum, and 11 volts for the energy corresponding to the highest frequency. Since these conclusions contradict the general belief that high potentials are necessary to excite these enhanced spectra, a series of *spectrograms* were made, with a large quartz spectrograph, of the light excited by low-voltage electrons in a special cylindrical tube in which the distance between the central tungsten filament, which supplied the electrons, and the accelerating grid was so short and the vapour pressure used was so low (0·1 to 0·2 mm. of Hg) that practically all the electrons entered the force-free space surrounding the grid, with the same energy. The voltages used varied from 3·5 to 5000 for Na, and from 3·5 to 40 for K. The results completely verify the theoretical conclusions. Tables and photographs are given which clearly show the *three-stage development* in the spectra of these elements: (1) Single pair stage: 2·1 to 5·1 volts (Na); 1·6 to 4·3 volts (K). (2) Arc spectrum stage: 5·1 to 30 volts (Na); 4·3 to 20 volts (K). (3) Enhanced spectrum stage: above 30 volts (Na); above 20 volts (K). With a heavy current (1 amp.) at 7 volts in K, the pair λ4642 becomes very prominent, though it has the series notation (1*s*–3*d*). Its presence cannot be due to incipient Stark-effect, and accordingly furnishes an exception to the principle of selection as applied by Sommerfeld. The *wave-lengths in I.Å. and the series notations*, when known, are given for 250 lines. AUTHORS.

1605. *Vacuum-Spark Spectra of the Metals.* **E. Carter.** (Mt. Wilson Observat., Contrib. No. 219. Astrophys. J. 55. pp. 162–164, April, 1922.)—*Vacuum-spark spectrograms of Ca, Mg, Cd, Ti, and Fe* were obtained *with comparison arc and spark spectra*, on portrait films, using for the most part a 20-cm. concave grating spectrograph. The Fe spectrum was also photographed with a dyed film from λ4000 to λ6000 Å. The new spectra show no striking new characteristics. In the case of Ca and also of Mg, the vacuum-spark spectrum is practically identical with the spark spectrum in air; in the case of Cd, the arc lines are somewhat more intense; with Ti this tendency to strengthen the arc lines is even greater, and the vacuum-spark spectrum of Fe is more like the arc spectrum than the spark. **Author.**

1606. *Structure of the Band Spectrum of Helium.* **W. E. Curtis.** (Roy. Soc., Proc. 101. pp. 38–64, April 1, 1922.)—The band spectrum of He was first described by the author and by Goldstein [Abs. 1433 and 1947 (1913)]. A preliminary examination of the author's photographs in the wave-length region λ6480 to λ3350 was made by Fowler [Abs. 557 (1915)], and Nicholson [Abs. 1257 (1915)] calculated new formulæ for the two series of double-headed bands found by Fowler, and concluded that they were analogous to principal series in line spectra. Further experimental work is described, and tables are given showing the wave-lengths, intensities, wave-numbers, and the allocation to series. Diagrams are also given which exhibit the structure of the different bands. It is shown that the quantum theory of band spectra is capable of accounting in a very simple manner for the structure of the He bands under consideration, and a brief resumé of this theory is given. In each of the three bands a new type of series has been found which, although closely related to the others, has not yet received a theoretical explanation. Other departures from the theory are also noted. It is concluded that the spectrum is due to an unstable He molecule, having a moment of inertia of about $1{\cdot}8 \times 10^{-10}$ gm.-cm.^{2}. **A. W.**

1607. *Minimum Electron Energies Associated with the Excitation of the Spectra of Helium.* **[Miss] A. C. Davies.** (Roy. Soc., Proc. 100. pp. 599–620, March 1, 1922.)—Experimental investigations here described have shown that none of the orthohelium and parhelium lines can be excited without all of them being stimulated, and that the ionisation of the atom is essential for their production. With the exception of this fact, all the results obtained, so far as they are concerned with these lines and with the line λ4686 of the enhanced series, are in accord with Bohr's theory of radiation. The necessity for the occurrence of ionisation before the emission of the orthohelium and parhelium series lines can take place seems, however, to indicate some limitation of those electron transitions within the helium atom which involve an increase in the potential energy of the atomic system, not predicted by Bohr's theory. The limitation is one which prevents direct transitions within the atom from the normal orbit to any orbits of either the crossed system or the coplanar system, except the 2,S and the 2,*s* orbits. The results of the present investigation are thus directly opposed to the conclusion drawn by Franck and Knipping that the bends in their current–voltage curves in helium between 21·2 and 25·2 volts are due to the excitation of successive lines of an ultra-violet series, by the return of the electron after displacement to successive outer orbits of the helium atom. On the other hand, the results of the investigation of normal uncharged He are in complete agreement with the results of McLennan and Ireton for Zn, Cd, and Hg, and of Foote and Meggers for Cs vapour. The excitation of λ4686 at voltages above 50·8 volts, and not below this value, indicates that a similar limitation does not hold in the stimulation of this line from a helium positive ion.

As regards the band spectrum of He, the results obtained, considered in conjunction with the recent conclusion of Horton and Davies [Abs. 1099 (1920)] that at 20·4 volts some system is produced in He which can be ionised by the radiation produced at 21·2 volts, support the suggestion made by Franck and Knipping that the coplanar atoms resulting from 20·4-volt electron collisions with He atoms are capable of forming He_2 molecules, which give rise to the band spectrum. [See Abs. 1174 and 1422 (1920).] A. W.

1608. *Significant Exception to the Principle of Selection; Potassium Spectrum.* **P. D. Foote, F. L. Mohler, and W. F. Meggers.** (Phil. Mag. **43.** pp. 659–661, April, and **N. Bohr,** pp. 1112–1116, June, 1922.)—A new form of discharge tube is described in which the *applied* electrostatic field can exert no influence upon the radiation. Using this tube, the lines 1*s*–3*d* were observed to be one of the most intense pairs in the potassium spectrum, with a current of 1000 mA, while at 70 mA their presence was not detected. The excitation of these lines, for which the change in azimuthal quantum number according to Sommerfeld is two units, is contrary to Rubinowicz's principle of selection as extended by Sommerfeld. It cannot be attributed to the Stark-effect of the applied exciting potential. This fact suggests that the extra components in the fine structure of the helium lines likewise may not be called out by the applied field. AUTHORS.

1609. *Minimum Resonance, Radiation, and Ionisation Potentials of Gases and Vapours.* **P. E. Boucher.** (Phys. Rev. 19. pp. 189–209, March, 1922.)—A special vacuum tube was used which embodied a modification of K. T. Compton's variable-area electrode by being so designed that either a gauze or a plate electrode could be slid into the position of the fourth electrode. The resonance potentials were obtained from the difference in voltage between successive peaks of the resonance curves; the ionisation potentials from Lenard current–voltage curves corrected as to zero by the resonance curves; the relative importance of radiation and ionisation at various voltages from the ratio of the Lenard currents obtained with the plate, to the corresponding currents obtained with the gauze electrode having only ¼ the area. The critical potentials in volts, accurate to about 0·1 volt except for toluene, are as follows:

Gas.	Resonance Potential.	Radiation Predominant.	Ionisation Potential.
Hydrogen	10·1	10·1 to 13·6	13·6; 15·6
Nitrogen	8·4	8·4 to 15·8	15·8
Oxygen	8·0	None detected	14·0
Ether ($C_4H_{10}O$)	6·6	8·1 to 10·1	13·6
Benzene (C_6H_6)	6·0	None detected	9·6
Toluene (C_7H_8)	6·2 ± 0·2	,, ,,	8·5 ± 0·5
Xylene (C_8H_{10})	6·5	,, ,,	10·0
Chloroform ($CHCl_3$)	6·5	,, ,,	11·5

The results for the resonance potentials for H_2, N_2, and O_2 agree with those obtained by Foote and Mohler, but the values for the corresponding ionisation potentials are about 1 volt higher than theirs. The fact that no radiation was detected in the case of O_2 and of all the vapours except ether is rather remarkable; but it may be due to the method used. AUTHOR.

1610. *Quantum Theory Interpretation of Voigt's Theory of the Anomalous Zeeman-Effect of the D-Lines Type.* **A. Sommerfeld.** (Zeits. f. Physik, 8. 5. pp. 257–272, 1922.)—A general outline of Voigt's theory is first given, and then it is shown how the quantum theory may be used. The result is a considerable simplification. Instead of separate formulæ for the positions of all the *p*- and *s*-components a single formula may be used, and single formulæ are also obtained for the intensities of the *p*- and the *s*-components. The paper concludes with a summary and brief discussion of the physical significance of the theory here advanced. [See Abs. 1441 and 1826 (1913).] A. W.

1611. *Appearance of Unsymmetrical Components in the Stark-Effect.* **A. M. Mosharrafa.** (Phil. Mag. 43. pp. 943–952, May, 1922.)—An approximate theory of the Stark-effect has been given by Schwarzschild and by Epstein [Abs. 781 (1916)]. These two theories are similar and give satisfactory explanations of the phenomena as investigated by Stark. According to their theory, the components into which any given spectral line is split up are symmetrically distributed about the original position of the line. In the present paper a closer approximation is worked out, and it is found that for stronger fields than those used by Stark this symmetry no longer follows from the theory. On the other hand, a pair of components which, for fields comparable with those used by Stark, appear symmetrically situated, would for stronger fields be displaced *in the same direction*, so that the symmetry is destroyed. It is also found that the relation between the strength of the field and the displacements of the lines is no longer represented graphically by straight lines, but by parabolic curves whose curvatures change sign with the displacements, i.e. displacements of opposite signs correspond to parabolas of opposite curvatures. Further experimental work with very strong fields is required. A. W.

1612. *Quantum Theory of Line Structure and of the Anomalous Zeeman-Effect.* **W. Heisenberg.** (Zeits. f. Physik, 8. 5. pp. 273–297, 1922.)—The first part of this paper deals with the structure of doublet and triplet atoms, the assumption being made that the line multiplicities are due to internal magnetic fields. The behaviour of such atoms in external magnetic fields is next investigated. The investigation demonstrates the agreement of the theory of the anomalous Zeeman-effect with experiment, and exhibits the transition to the Paschen-Back effect. Quantitative results are obtained for the doublet and triplet distances, and a simple formula is obtained for the ratio of the triplet distances which gives results in good agreement with experiment. [See Abs. 132 and 904 (1922).] A. W.

1613. *Fluorescence and Photo-Chemistry.* **R. W. Wood.** (Phil. Mag. 43. pp. 757–765, April, 1922.)—Perrin has shown that thin films of a solution of fluorescein were bleached at the spot on which the light was focused by the substage parabolic reflector of a microscope. He also found with other fluorescent substances that in all cases they were bleached with greater or less rapidity by the action of light. By operating with a very intense beam of sunlight the author has been able to obtain sufficient quantities of the transformation products produced by the action of light on fluorescent solutions to make possible an examination of their optical and chemical properties. The time required to effect the change varies with the nature of the substance: eosin is completely changed in two or three minutes, while rhodamine in the same concentration requires several hours. Usually the decomposition of the fluorescent substance by the action of light yields a coloured non-fluorescent substance which is bleached by the further action of the light to a colourless solution. This makes it impossible to obtain the intermediate substance in a pure state; but by choosing the proper concentration and stopping the illumination at the right moment it was possible to obtain fairly satisfactory results.

The absorption spectra of the various compounds were photographed. Photographic reproductions are given of some of the results obtained. The intermediate coloured substances have been called *photo-compounds.* Fluorescein (uranine), which is lemon-yellow by transmitted light, is changed into a non-fluorescent compound (photo-fluorescein) which is orange-red and has an absorption band of a totally different form. The fluorescein band is very steep on the red side, sloping down gradually towards the region of shorter wave-lengths. The band shown by photo-fluorescein, however, is more nearly symmetrical. It is to this peculiarity that the red colour is due. Continued illumination eventually bleaches the compound. Eosin behaves in a similar manner, the action of the light being, however, more rapid. Rhodamine behaves in a very peculiar manner, different results being obtained with aqueous and alcoholic solutions. It seems probable from the experiments that rhodamine may be a mixture of two substances. A number of other substances, including phloxine, resorufin, acridine orange, and naphthalene red, were also examined. The effect of temperature on fluorescence was also investigated for some substances.

A remarkable relation between the rate of breakdown of eosin and the intensity of the exciting light was discovered, which has probably a very direct bearing on Perrin's theory. It was found that high intensities acting for a short time produce a greater amount of decomposition than low intensities acting for a long time, the time being increased in proportion to the reduction in intensity. This means that the change is not proportional to the amount of energy extracted from the incident light, a result which is at variance with the Bunsen-Roscoe law.

A. W.

1614. *Radiology and Physics.* **G. W. C. Kaye.** (Engineering, 113. pp. 352–353, March 24, 1922. Mackenzie Davidson Memorial Lecture delivered before the Roy. Soc. of Medicine. Nature, 109. pp. 414–416, April 1, 1922.)—The lecturer refers to the possibility of there being X-ray radiations as yet undiscovered, since there is a gap of four octaves between the shortest wave-length of ultra-violet light and the longest X-ray radiations known. A range of radiations, the " J " series, is believed to exist below the K, L, and M series and 13 octaves are believed to exist between 500 to 0·06 Å.U., or 16 octaves if γ-rays are included, from 1·4 to 0·01 Å.U. A bulb gives a " white " radiation proportional to V^2 and for certain critical values definite spectral lines, the relations being, for voltages and wave-lengths of the M, L, K, and J series respectively, 2500, 13,000, 75,000, 180,000 and more, volts and 5·2, 0·96, 0·17, 0·07 Å.U. Special bulbs able to withstand 200,000 volts will be necessary for the J rays. Practical radiology is limited to the K series; the general radiation and the L and M radiation only slightly penetrate the glass walls of the bulb.

There is a definite boundary or quantum limit to every general X-ray spectrum on the lower side; this depends on the exciting voltage and not upon the target metal; it is related as $Ve = h\nu$, where V is the max. potential, ν the frequency of shortest wave λ_0, h is Planck's constant, and e the electronic charge. We can deduce λ_0 from the max. volts V or by a measurement of the quantum limit by means of the Seemann direct-reading spectrometer, a brief description of which is given. The L series of waves can be generated without the K series, but not the K series without the L. B. J. L.

1615. *Röntgenograms of Strained Crystals.* **A. F. Joffe and M. V. Kirpitcheva.** (Phil. Mag. 43. pp. 204–206, Jan., 1922.)—An interesting method of studying strain in crystals by means of Laue's röntgenograms is described. The simplest case studied is that of a homogeneous strain (*e.g.* a compression) of rock salt, loading it gradually by means of an electromagnet. After the limit of elasticity is passed the separate spots of Laue's diagram begin to elongate and to form a figure similar to that reproduced in the original paper. The detailed photograph of a crystal not too much strained shows in every elongated spot a stratification, consisting of a series of separate spots, the number of which increases with the increase of the strain. This stratification is ascribed to separate small crystals (each a few hundredths of a mm). into which the whole crystal has parted. The photograph indicates also the direction in which the small crystals slide. The spot corresponding to the rhombical dodecahedron (110) remains quite unaltered, while the others become elongated. The authors conclude that a crystal of rock salt, when compressed, breaks up into small crystals, which, while sliding along the plane of the rhombic dodecahedron, rotate at the same time through different angles. The structure of the small crystals is shown to be the same as that of the original crystal. Quartz does not show any diffused spots until it breaks, its limits of elasticity and durability being the same.

Determination of Elastic Limit for Different Materials.—The method described is a very convenient one for the determination of the limit of elasticity of different materials, and also for the study of the manner of their destruction. A method is also described which gives on two photographs the strains in every direction, and all the constants of elasticity are quickly determined from one small sample of crystal. A. B. W.

1616. *L-Doublet of Neon.* **W. Grotrian.** (Zeits. f. Physik, 8. 2. pp. 116–125, 1921.)—The author deduces that the gases He, Ne, Ar, and Kr must have one, three, five, and seven ionisation potentials respectively. In the case of neon, it has been shown that the doublet difference $L_2 - L_1$ is identical with Paschen's constant $A = 782$ cm.$^{-1}$ for the spectrum of neon. A. B. W.

1617. *Spectrum of Secondary X-Rays.* **A. H. Compton.** (Phys. Rev. 19. pp. 267–268, March, 1922.)—In an earlier paper (*ibid.*, 18. p. 96, 1921) the author has shown that the secondary rays excited in different materials when X-rays, rendered nearly homogeneous by filtering were employed, are of a softer type than the primary rays striking the radiator. More recent experiments [Abs. 900 (1922)] have shown that this phenomenon is not confined to heterogeneous X-rays, but occurs also when the rays incident on the radiator have been reflected from a crystal. In order to obtain more definite information with regard to the characteristics of the secondary X-radiation, a study has been made of the spectrum of the secondary rays excited in various substances by the X-rays from a Coolidge tube having a Mo target. A small piece of radiating material, such as celluloid or Al, placed in front of the first slit of the spectrometer, was illuminated by incident X-rays at approximately 90° with the secondary beam under examination. The spectrum was studied by means of a calcite crystal grating, using both the ionisation and photographic methods. The spectra obtained show lines identical in wave-length with the primary K lines from Mo, thus proving that a part of the secondary radiation is truly scattered and unchanged in wave-length. In addition to these lines, a general radiation is observed which is more prominent in the secondary than in the primary beam. The energy in this general radiation is roughly 30 % as great as the energy of the scattered K-rays. Previous experiments have shown that when shorter wave-lengths are employed, the energy of the fluorescent rays may be even more prominent than the truly scattered rays. A. B. W.

1618. *Reflection of X-Rays from Imperfect Crystals.* **C. G. Darwin.** (Phil. Mag. 43. pp. 800–829, May, 1922.)—The recent work of Bragg, James, and Bosanquet [see Abs. 1773 (1921)] on the reflection of X-rays from rock-salt crystals is of extreme importance in that it promises more directly than any other method to supply information about the actual positions which the electrons occupy in the atom. The method consists in a study of the intensity with which the various faces of the crystal reflect a given wave-length, and is based on the theoretical formulæ given by the author [Abs. 1079 and 1262 (1914)]. These formulæ showed that such experiments should determine a certain quantity, which is, roughly speaking, the amplitude of the wave scattered by all the electrons in a single atom in the direction of the reflected beam. A study of the various faces of a crystal gives this amplitude as a function of the angle of scattering, and from that the positions of the electrons can be inferred. The author is now concerned with this second half of the problem, but the deduction of the amplitude from experimental data involved certain peculiar difficulties—particularly those relating to the absorption coefficient of the crystal. A complete mathematical analysis for the case of reflection from the faces of an "imperfect crystal" is now given and a comparison is made of the theoretical formulæ with known experimental results. Although the agreement in such comparisons is not all that could be desired, the theory opens up promising lines of investigation for further experimental work. A. B. W.

1619. *Increased Accuracy in X-Ray Spectrum Measurements.* **I. M. Siegbahn.** (Zeits. f. Physik, 9. 1 and 2. pp. 68–80, 1922.)—The author deals with the various methods of increasing the accuracy in X-ray crystal measurements. The effect of width of slit on width of spectrum lines is discussed, and a special form of X-ray tube is described. The original paper should be consulted. A. B. W.

1620. *Influence of Magnetic Field on the Emission of X-Rays.* **F. J. de Wisniewski.** (Arch. des Sciences, 4. pp. 120–128, March–April, 1922.)—A mathematical paper not permitting of a short abstract. A. B. W.

1621. *Spiral Filaments and Ring Filaments in X-Ray Diagrams.* **K. Weissenberg.** (Zeits. f. Physik, 8. 1. pp. 20–31, 1921.)—Herzog and Jancke, by radiating certain fibrous (*faseriger*) biological preparations (muscles, nerves, tendons, hairs) with monochromatic X-rays, have observed certain symmetrical diagrams on the photographic record. There is a certain similarity in nature between these diagrams and those obtained in the Debye-Scherrer method in which so-called amorphous substances are radiated by X-rays. The author now examines the possible origin of such "Faser" diagrams in the case of substances with axial symmetry. Two forms are considered in detail, namely, "spiral" and "ring" filament diagrams. A. B. W.

1622. *X-Ray Fibre Diagram* (*Faser-diagramm*). **M. Polányi and K. Weissenberg.** (Zeits f. Physik, 9. 1 and 2. pp. 123–130, 1922.)—A theoretical paper in continuation of earlier work. [See preceding Abs.] A. B. W.

1623. *Scattering of X-Rays from Carbon.* **C. W. Hewlett.** (Phys. Rev. 19. pp. 265–267, March, 1922.)—Measurements have been made of the scattering of homogeneous (molybdenum Kα, $\lambda = 0{\cdot}712$ Å.) X-rays from substances containing carbon and an estimate is made of the amount of scattering per gm. of carbon. The scattering of powdered artificial graphite, liquid mesitylene, and diamond chips was measured between 2° and 158° from the incident beam. The results are given below:

Substance.	Density.	True Mass Absorption Coefficient.	Mass Scattering Coefficient.
Mesitylene	0·863	0·351	0·184
Graphite	1·48	0·351	0·198
Diamond	3·51	0·351	0·234

Theory predicts a large intensity of scattering at very small angles, but these experiments show that the scattering approaches zero at these small angles. A. B. W.

1624. *Corpuscular Spectra of the Elements.* **M. de Broglie.** (Comptes Rendus, 174. pp. 939–941, April 3, 1922.)—In continuation of previous papers on this subject [Abs. 575 and 576 (1922)] the author gives the results of his investigation of the corpuscular spectra of silver, tin, gold, and uranium. A. B. W.

1625. *Degree of Accuracy of Bragg's X-Ray Law.* **M. Siegbahn.** (Comptes Rendus, 174. pp. 745–746, March 13, 1922.)—In various publications in 1919 and 1920, Stenström and Hjalmar have shown that Bragg's law of reflection of X-rays requires a slight correction. Actually, this law does not give exactly the same value of wave-length calculated for reflections of different order. The discrepancy between calculated and observed values of wave-length for different orders is not much greater than experimental error, but systematic deviations observed make the correction without doubt. Stenström and Hjalmar demonstrated the inaccuracy in the case of gypsum and calcite; experiments by the author [see Abs. 572 (1922)] confirmed their conclusions in the case of calcite. Dauvillier in a recent note [Abs. 912 (1922)] has criticised these observations, suggesting the apparent divergence from Bragg's simple law to be due to the complex nature of the $K\alpha_1$ line in the measurements.

The author now refutes Dauvillier's contention, showing that the result is the same for the $K\alpha_2$ line (which Dauvillier admits is simple).

A. B. W.

1626. *Absorption of Short X-Rays by Al and Cu.* **W. Duane** and **K. C. Mazumder.** (Nat. Acad. Sci., Proc. 8. pp. 45–49, March, 1922.)—The authors find that the following equations represent the coefficients of absorption according to their measurements in the region of short wave-lengths ($\lambda = 0\cdot095$ to $0\cdot165$): For Al, $\mu/\rho = 15\cdot5\lambda^3 + 0\cdot147$; for Cu $\mu/\rho = 193\lambda^3 + 0\cdot13$. By means of these relations it becomes possible in any practical case to determine the "effective" wave-length for a beam of X-rays by simply measuring the fraction of the radiation that passes through a plate of Al or Cu. A. B. W.

1627. *Scattering of Electrons by Nickel.* **C. Davisson** and **C. H. Kunsman.** (Phys. Rev. 19. pp. 253–255, March, 1922.)—The emission from a nickel target under bombardment by electrons has been found to contain a small fraction of electrons of speeds comparable with the speed of the incident electrons for bombarding potentials at least to 500 volts. No certain difference has been found between the speed of the fastest of these electrons and the speed of the primaries.

The author has studied the emission of these electrons at different orientations relative to the direction of the primary beam, and finds two directions at which maxima are observed; one of these maxima being dependent on the voltage of excitation of the primary rays. A. B. W.

1628. *The K_α-Doublets; New Determination of the Grating Constants of some Crystals.* **W. Gerlach.** (Phys. Zeits. 23. pp. 114–120, March 1, 1922.)—A method is described for the measurement of the fine structure of X-ray spectral lines. A number of grating constants of certain crystals have been determined:—

Silicon	$5\cdot415 \times 10^{-8}$ cm.	($\pm$ 0·3 %)	(copper radiation)
	$5\cdot410 \times 10^{-8}$ cm.	($\pm$ 0·3 %)	(nickel radiation)
Regular zinc blende	$5\cdot390 \times 10^{-8}$ cm.	($\pm$ 0·3 %)	(copper radiation)
Calcium fluoride	$5\cdot455 \times 10^{-8}$ cm.	($\pm$ 0·1 %)	(copper radiation)
	$5\cdot478 \times 10^{-8}$ cm.	($\pm$ 0·2 %)	(nickel radiation)

The doublet difference $K_{\alpha_2} - K_{\alpha_1}$ has been determined with an accuracy of 3 %; for copper it is 3·84 X.U. and for nickel 3·77 X.U.

[N.B.—1 X. unit = 10^{-11} cm.] A. B. W.

1629. *Photographic β-Ray Measurements.* **W. Bothe.** (Zeits. f. Physik, 8. 4. pp. 243–250, 1922. From the Physikal-Techn. Reichsanstalt.)—The paper describes a photometric method of measuring intensities of lines in β-ray spectra or in any other type of photographic impression by radiation. Using this method a test has been made of the law of "blackening" due to Schwarzschild, namely: $S = f(it^p)$, where S is a measure of the "blackening" of the film, i the intensity of the incident radiation, and t the time of exposure. Observations with β-rays (ranging i and t) give the following values of p: 0·989, 0·998, and 1·008; a mean $p = 1·00 \pm 0·01$. That is, the blackening of a plate is directly proportional of the intensity of the β-radiation and to the time of exposure of the plate to the rays. A. B. W.

1630. *Distribution of Activity in Radium-Therapy under Different Conditions of Screening.* **H. H. Poole.** (Roy. Dublin Soc., Proc. 16. pp. 467–477, April, 1922.)—The author has determined experimentally the absorption effects of various materials when radiated by α-, β-, or γ-rays from tubes of RaEm; particular attention being paid to the application of the results to radium therapy. The materials used for absorption screens were generally cardboard and leather (as approximating to animal tissue). The effect of distance was investigated when needles or "large surface applicators" were used, and the following points are noted: (1) The very great activity of emanation in needles at moderate distances; (2) the great reduction in surface effect caused by increasing the distance of the capillaries from the skin; (3) the still greater reduction in surface effect due to increase of area. In the case of treatment with several parallel needles, each containing a tube 15 mm. long, the distribution of activity in a perpendicular plane through their centres can be found by summing the effects of the separate needles at any required point. A. B. W.

1631. *Radium Content of Sealed Metal Tubes.* **E. A. Owen** and **B. Naylor.** (Phys. Soc., Proc. 34. pp. 92–97, April, 1922.)—Tables have been compiled giving the corrections that have to be applied to the observed radium content of sealed platinum and silver tubes to obtain their true radium content. Two cases have been considered, namely, (1) that in which the active deposit is uniformly distributed throughout the volume of the tube such as in a full tube of salt, and (2) that in which the active deposit is uniformly distributed over the inner wall of the tube, such as in a tube containing a minute quantity of highly concentrated salt. The results show that when the wall thickness is kept constant, the correction increases with the external diam. of the tube. Also for the same increase of external diam., the increase of correction is more pronounced for the "empty" than for the full tube. AUTHORS.

1632. *Multiple Valency in the Ionisation by α-Rays.* **T. R. Wilkins.** (Phys. Rev. 19. pp. 210–220, March, 1922.)—*Valency of Ions Produced by α-Rays.*—The Millikan oil-drop method was used with slight modifications which simplified the procedure. *In air,* out of 350 positive ions produced by X-rays at the end of their range, only 3 % could have been doubly charged, and most if not all of these were probably not doubles but two successive singles. *In helium,* an extensive series of 2150 positive catches were observed with gradually increasing pressure to determine not only whether doubles were produced but also the *variation of the number of doubles with the range.* It was found that an appreciable proportion of real doubles is produced when the ranges of the rays are equivalent to between 4 and 30 mm. of helium at atmospheric pressure, the max.

proportion being about 10 %, for the range of maximum ionising power. That this result was real was proved by the fact that when *hydrogen* was substituted, even for the range of max. ionisation, the proportion of apparent doubles was only 5 out of 200 positive ions. The previously reported negative result for *mercury dimethyl* was confirmed.

The *relative stopping power for α-rays, of air and helium,* came out close to 3·8, in agreement with the Bragg-Kleeman law. AUTHOR.

1633. *The Number of Radio-Active Transformations as Determined by Analysis of the Observations.* **H. Levy.** (Phys. Soc., Proc. 34. pp. 108–111; Disc., 112–113, April, 1922.)—It is known that the expression for the *n*th product of a series of radio-active transformations is properly represented as the sum of *n* terms of the type $a_n e^{-\lambda_n t}$. When *n* is known, the coefficients a_n and λ_n are determinable with comparative ease. The present paper finds a criterion for determining *n*, the number of transformations, when this is not known from *a priori* considerations. This consists in the successive evaluation of a system of simple determinants easily constructed from the observations. The value of *n* is at once found from the order of the particular member of the system that vanishes. AUTHOR.

1634. *Distribution of Range of Recoil Atoms.* **K. T. Compton.** (Phys. Rev. 19. pp. 233–236, March, 1922.)—*Number and Range of Recoil Rays, Produced by α-Ray Bombardment, to be Expected on the Assumption of the Inverse Square Law of Force between Nuclei.*—In calculating these quantities for comparison with his experimental results for hydrogen, Rutherford took account only of impacts occurring at the slit, whereas recoil rays may reach the screen from other points. In this note is given a method of calculating the exact number of recoil rays, for a given thickness of absorbing screen, to be expected with the experimental arrangement used for gases by Rutherford. The results for hydrogen come out about 30 % larger than those computed by Rutherford; but this fact does not invalidate his conclusion that the difference between experimental and theoretical curves indicates a law of force other than the inverse square in the case of collisions by high-velocity α-particles. AUTHOR.

1635. *Luminous Tracks of α-Rays in Crystals.* **H. Geiger** and **A. Werner.** (Zeits. f. Physik, 8. 3. pp. 191–192, 1922. From the Physikal.-Techn. Reichsanstalt.)—A microscopic examination of the luminous tracks produced by α-rays in various "scintillating" materials, viz., zinc sulphide, diamond, willemite, etc. From the length of the luminous track in a thin slip of willemite crystal it was estimated that the range of polonium α-particles in this crystal was about 0·02 mm. A. B. W.

1636. *Tracks of α-Particles on the Photographic Plate.* **E. Mühlestein.** (Arch. des Sciences, 4. pp. 38–63, Jan.–Feb., 1922.)—After reviewing the work of Makower and Walmsley, Sahny, Ikeuti, and others on this subject, the author describes a new method of producing the tracks of α-particles in photographic films. In the method employed the "infected" plate is immersed in mercury during the period of exposure, as a result of which the radiographs are sharp circular haloes, having the active particle in the centre.

The radius of these haloes gives the range of the α-particles in the sensitive layer. Thus the α-rays from RaC have a range of 500 μ, whilst the polonium α-rays have a range of 27·7 μ. The ratio of these ranges is sensibly the same as for the corresponding value for the ranges of the same α-particles in air—the dimensions of the active nucleus being practically negligible. A point source of radio-active material placed on the surface of a photographic layer of sufficient thickness has been shown to produce a definite impression of hemispherical form. Measurements have been made of the number of silver granules affected in the track of each α-particle, and the results applied to the counting of α-particles by this means. As yet, however, the observations are incomplete. A. B. W.

1637. *Stopping Power and Atomic Number.* **J. L. Glasson.** (Phil. Mag. 43. pp. 477–481, March, 1922.)—Certain properties of the atom are more simply and accurately expressed in terms of atomic number than in terms of atomic weight. The present paper is an attempt to examine the truth of this in regard to the atomic property known as the "stopping power" for α-rays. Bragg showed that the stopping power of an atom is proportional to the square root of its atomic weight. The original data given by Bragg are now examined, and it is shown that "the stopping power of an atom is proportional to its atomic number raised to the power two-thirds." A. B. W.

1638. *β-Ray Spectra and their Meaning.* **C. D. Ellis.** (Roy. Soc. Proc. 101. pp. 1–18, April 1, 1922.)—The author summarises as follows:—(1) A general method for measuring the wave-length of γ-rays is described. (2) The analysis of the β-ray emission of RaB has been completed. (3) The lower energy section of the RaC β-ray spectrum has been analysed by the excited spectrum method and the γ-rays found. (4) The β-ray spectrum of ThD has been measured and the effective γ-rays deduced. (5) It is shown that it is very probable that the γ-rays of radio-active bodies are emitted from the nucleus. (6) Evidence is brought to show that the quantum dynamics applies to the nucleus, and suggestions are given for the arrangement of the nuclear levels of RaB and ThD. A. B. W.

1639. *Origin of β-Ray Spectra of Radio-Active Substances.* **L. Meitner.** (Zeits. f. Physik, 9. 3. pp. 131–144, 1922.)—An investigation is described of the production of secondary β-rays in Pb and Pt by the γ-rays from ThB. It is shown that β-ray spectra of radio-active substances may be divided into two parts: a primary spectrum originating in the nucleus (nuclear-β-rays), and a secondary spectrum from the electron rings (ring-β-rays). Good agreement was found between the calculated and observed velocities of both primary and secondary β-ray groups from ThB. The observed relative number of primary and secondary β-ray groups for RaD was found also to be in good agreement with theory. The knowledge now obtained in the case of the primary β-rays provides a direct means of calculating the wave-length of the γ-radiation. A. B. W.

1640. *Relation between β- and γ-Rays.* **L. Meitner.** (Zeits. f. Physik, 9. 3. pp. 145–152, 1922.)—In another paper [see preceding Abs.] the author has shown that the β-ray spectrum of a radio-active substance consists of two parts. It is now shown that the primary (nuclear) β-ray originates in the nucleus a corresponding γ-radiation. This γ-radiation passes unchanged through the outer electron system exciting therein secondary

β-rays. Thus a "characteristic" nuclear γ-radiation is produced, the nature of which is quite independent of the outer electron system of the atom in which it originated. A. B. W.

1641. *Radio-Activity of all the Elements: Experimental Test.* II. **G. Hoffmann.** (Zeits. f. Physik, 7. 4 and 5. pp. 254–259, 1921.)—By means of a very sensitive method of detecting the presence of the ionisation produced by even a single α-particle [see Abs. 1433 (1920)], the author now demonstrates the emission of α-particles (or similar radiation) from a Pt surface. The apparatus used is described in detail in the previous paper. A. B. W.

1642. *Haloes and Earth History: A New Radio-Active Element.* **J. Joly.** (Nature, 109. pp. 517–518, April 22, 1922.)—In the Archæan black mica of Yitterby, very small, colourless, spherical, halo-like forms occur. The mica is, as it were, bleached within these halo-spheres. Many show a central opaque particle or nucleus. In the case of others it is difficult to be sure of the presence of a nucleus, or it may take the form of a limpid refracting particle. The optical appearances suggest that in these spheres the refractive index of the mica has been raised. The average diam. of the haloes appears to be 0·01 mm.; no allowance being made for the nucleus. The bleached appearance of the haloes suggests that the Archæan micas were at some remote period subjected to a temperature not much exceeding 700° C. during which a prior-existing crop of haloes were obliterated or reversed. Within some of the haloes a small ring of radius about 0·005 mm. is sometimes seen. Assuming this to be due to α-radiation, it corresponds to a range of 1 cm. in air at N.T.P. The element emitting it must have a period some billions greater than that of uranium according to an interpolation on the Geiger-Nuttall curve. It is thus probable that another radio-active element exists of extremely great period and emitting α-rays of 1 cm. range. The author suggests the name "Hibernium." A. B. W.

HEAT.

1643. *A Continuous-Flow Calorimeter, and Determination of Heat of Neutralisation.* **F. G. Keyes, L. J. Gillespie, and S. Mitsukuri.** (Am. Chem. Soc., J. 44. pp. 707–717, April, 1922.)—A continuous-flow calorimeter has been so developed that measurement of the rise of temperature for 10 rates of flow leads to a value of the heat of neutralisation, the "probable error" of which is calculated by least squares to be less than 0·1 % of the heat itself. For the heat of neutralisation resulting in the formation of $NaCl . 521 H_2O$ (about 0·107 *N* sodium chloride) at 32·3°, the authors find 13,280 cals. per mol. This value is 2·6 % higher than the corresponding point on the curve of Wörmann for the same neutralisation. L. H. W.

1644. *Coefficient of Thermal Expansion.* **H. C. Knerr.** (Chem. and Met. Eng., 26. pp. 644–646, April 5, 1922.)—As a special problem it was required to measure the expansion of bars, 3 in. long, of a light alloy. A specimen was inserted between a bar of steel and one of duralumin. A common face of the three was rubbed down flat and this face was highly polished. Two fine lines were traced across the face, one at each end of the face, and the expansion of the alloy was deduced by knowing those of the other two materials, and observing the movements of the lines as the temperature was raised in a thermostat. A peculiar feature is that the metallurgical microscope used for the measurements was used *below* the thermostatic bath, there being windows let in the bottom of the latter for the purpose of observation. P. E. S.

1645. *Effect of Pressure on the Thermal Conductivity of Metals.* **P. W. Bridgman.** (Am. Acad., Proc. 57. pp. 77–127, April, 1922.)—Two methods are described for measuring the thermal conductivity. The first is a radial flow method; the second is a longitudinal flow method, the essential of which is the small size of the specimen. The irregularities of the individual readings by the second method are greater than by the first method, but the effect of inhomogeneities is less and different specimens of the same metal will give the same result.

Measurements of the effect of pressures to 12,000 $kg./cm.^2$ on the thermal conductivity of 11 metals have been made by one or the other of these methods. The effect may be either positive or negative, and is more often negative than positive. In only two cases, lead and tin, does the Wiedemann-Franz ratio increase under pressure; for the other metals it decreases, and sometimes by large amounts. In addition to the metals, the pressure coefficient of thermal conductivity of petroleum ether has been measured. The conductivity increases by a factor of about 2·2.

The only previous measurements have been by Lussana, who obtained results entirely different from those found here. His method is criticised in some detail, chiefly on the basis of the uncertain correction for the lateral loss of heat to the pressure-transmitting medium.

These results indicate that a fairly large part of thermal conduction in a metal is performed by the atoms. Theoretical reasons are given for estimating the atomic contribution to the thermal conductivity as 50 % of the electronic contribution. AUTHOR.

1646. *Thermal Conductivity of Cast Iron; Variation with the Temperature.* **E. E. Hall.** (Phys. Rev. 19. pp. 237–240, March, 1922.)—The sample used contained 3·5, 2·2, and 0·64 % of C, Si, and Mn respectively, and was cast into the form of a cylindrical shell 3 cm. thick, joined with a hemispherical bottom. The temperature differences between the liquids inside and outside the shell, which amounted to from 3 to 6 deg. with an input of from 0·24 to 1·6 kw., were measured with thermo-couples silver-soldered in the ends of brass tubes. Since even though these tubes were pressed against the iron surfaces, the temperatures thus measured differed more or less from the actual temperatures of the surfaces, the absolute values found for the conductivity are too low; but the results indicate that the conductivity at 542° is between 2 and 3 times its value at 195° C. AUTHOR.

1647. *Redetermination of the Melting-point of Sodium Chloride.* **J. B. Ferguson.** (Roy. Soc. Canada, Trans. 15. Sect. 3. p. 50, 1921.)—In connection with the calibration of a thermo-couple the melting-points of zinc, antimony, silver-copper eutectic, sodium chloride, silver, and copper were determined. All were found in good agreement with the accepted values except sodium chloride. Samples of the pure salt from various sources gave melting- and freezing-points within a few microvolts of each other; a White potentiometer with eliminating switch was used, the position of the junction in the melt was varied, and all the usual precautions were taken. There seems little room for doubt that the accepted value 801° ± 1° is at least one degree too low. AUTHOR.

1648. *The Born-Brody Theory of the Specific Heats of Solid Bodies at High Temperatures.* **A. Magnus.** (Zeits. f. Physik, 7. 2. pp. 141–143, 1921.)—Evidence is given from the author's measurements on Pt of the validity of the law advanced by Born and Brody [see Abs. 1154 (1922)], that at high temperatures, in cases where the atomic heat C_v gives a higher value than 3R or 5·956 cals., its temperature slope will be linear, and when extrapolated to the absolute zero will give the value 3R to within about 1 or 2 %. In the formula $C_p - C_v = 9\alpha^2 AT/\chi\rho$, the denominator may be taken as a constant, as the compressibility χ increases, while the density ρ decreases with temperature, both being small. The atomic weight A being constant, $C_p - C_v$ depends only on changes of α and T. Measurements on the coefficient of expansion α for Pt give a straight-line curve which on being extrapolated to the absolute zero gives the value 5·957 for C_v. Results for Cu at high temperatures published by Frazier and Richards lead by extrapolation to the value 5·93, which again is very near that required by the Born-Brody theory. The lower value of 5·5 found by the author and Lindemann for some other metals is discussed and reasons are given for the deviation from that to be expected from the theory. T. B.

1649. *Temperature Changes in an Incandescent Filament, and the Specific Heat of Tungsten.* **K. K. Smith** and **P. W. Bigler.** (Phys. Rev. 19. pp. 268–270, March, 1922.)—Describes experiments on the temperature changes which take place in a filament heated by means of an alternating current of 60 cycles per sec. The temperature variations were measured by means of the thermionic emission, a simultaneous photographic record being obtained of both the magnitude of the emission current and the variations in the alternating voltage across the filament. From known observations on the change in thermionic current resulting from a known change in temperature, the measured variations of emission are translated into oscillations of temperature. The lag of temperature behind the power is found on the assumption that the thermionic emission is in phase with the temperature. Using Corbino's expression for the heat capacity of the wire, variations of temperature of the order of 25 deg. were found with a mean temperature of 2450° K, and the specific heat of the filament was found to be 0·0479 cal./gm. deg. It is concluded that the thermionic emission gives a satisfactory method of recording rapid changes in the temperature of a filament. J. W. T. W.

1650. *Determination of the Higher Point of Inversion of the Specific Heat of Saturated Benzene Vapour.* **G. Bruhat** and **A. Delaygue.** (Comptes Rendus, 174. pp. 937–939, April 3, 1922.)—For certain substances the specific heat of the saturated vapour exhibits two inversion points. At low temperatures and in the neighbourhood of the critical point, the specific heat is negative and the initiation of the adiabatic stage of the saturated vapour is accompanied by partial condensation. In the interval of temperature between the two inversion points the specific heat is positive and it is the adiabatic compression of the saturated vapour which produces condensation. By means of a Cailletet apparatus with the tube surrounded by a jacket containing glycerine electrically heated, determinations have been made of these inversion points for benzene vapour, the values obtained being 122° and 258°. A theoretical investigation of the specific heat of benzene vapour, starting from the characteristic equation for benzene in the Clausius form, and from the calorimetric constants, heat of vaporisation, and specific heat of the unsaturated vapour, leads to the values 121° and 254° for these inversion temperatures. T. H. P.

1651. *The Specific Heats of Air, Steam, and Carbon Dioxide.* **R. T. Glazebrook.** (Roy. Soc., Proc. 101. pp. 112–114, April 1, 1922.)—Attention is drawn to some discrepancies in a paper bearing the above title by W. D. Womersley [Abs. 1331 (1922)]. Holborn and Henning [Abs. 1858 (1907)] gave experimental values of mean specific heats at constant pressure between 0° C. (or 100° C.) and the temperature of the observation. These were transformed by the author named into mean volumetric heats per gm.-molecule, and it is pointed out that errors amounting in some cases to 6 or 8 % have been made in the calculation. The paper is criticised further on other grounds. T. B.

1652. *Combustion of Complex Gaseous Mixtures.* **W. Payman** and **R. V. Wheeler.** (Chem. Soc. J., Trans. 121. pp. 363–379, March, 1922.)—The speed of the uniform movement of flame in limit mixtures with air is, under standard experimental conditions, approximately the same for the paraffin hydrocarbons up to pentane, viz. about 20 cm. per second in horizontal glass tubes of 2·5 cm. diameter, the speed being generally a few cm. larger for the lower limit mixture than for the upper limit mixture [see Abs. 731 (1920)]. When two limit mixtures (both upper or both lower) are mixed, the resultant flame speed remains unchanged for all proportions of the two mixtures. A consequence of this "law of speeds" is that, when mixtures of hydrogen and air and of methane and air containing insufficient oxygen are separately exploded and their combustion products then mixed, these combustion products are the same that the complex mixture would yield, though the secondary water-gas reaction modifies the distribution of oxygen between the hydrogen and the methane. This is confirmed by various experiments, particulars of which are given. The authors differ from Bone as to the apparent greater affinity of methane for oxygen than either hydrogen or carbon monoxide, and as to the division of the oxygen between CH_4 and H_2 during the extremely short period of actual oxidation which, they consider, is not instantaneous. When oxygen is in defect the methane must combine with the major portion of the oxygen, because the methane-oxygen association that is required to yield the same flame speed as the H-O association is the richer in oxygen. H. B.

1653. *Kinetic Theory of a Special Type of Rigid Molecule.* **F. B. Pidduck.** (Roy. Soc., Proc. 101. pp. 101–112, April 1, 1922.)—The paper is "an exercise in the classical kinetic theory, with no admixture of quantum theory, or of the modern theory of atomic structure." The molecular model adopted is one suggested by Bryan (Brit. Assoc. Rep., p. 83, 1894). Two spheres collide and grip each other, so as to bring the points of contact to relative rest. A small elastic deformation is produced, which is released immediately afterwards, the force during release being equal to that at the corresponding stage of compression. The paper discusses the effect of energy of rotation on viscosity and thermal conductivity. T. B.

1654. *Kinetic Theory of Solids (Metals) and the Partition of Thermal Energy.* I *and* II. **B. M. Sen.** (Phil. Mag. 43. pp. 672–687, April, 1922.)—While the kinetic theory of gases has been developed in great detail, hardly any progress has been made with that of solids. In the absence of any such well-developed theory, attempts are sometimes made to apply the results of the kinetic theory of gases to the case of solids, *e.g.*, in the theory of electric conduction. The results can hardly be regarded as satisfactory, one fundamental assumption of the gas theory being that the volume of the molecules is negligible in comparison with that of the gas itself, an assumption which does not hold good even approximately for solids. Lately Nernst and others have approached the subject from the standpoint of Planck's quantum theory, and the present author now attempts to develop the theory for metals on the basis of classical mechanics. He assumes repulsion to be of the nature of an impulse due to what are called impacts in the kinetic theory of gases, and that the amplitude of vibration is small in comparison with the atomic dimensions. The results obtained completely bear out the assumption. Section 1 gives some numerical values; section 2, considers the arrangement of molecules in an isotropic body; while section 3 describes a rough working model of 14 molecules placed on a sphere about each individual molecule at the centre; (4) investigates the potential energy of displacement; (5) discusses the order of magnitude of the kinetic and potential energy terms; (6) deals with heat relations; (7) derives the partition of energy, assuming that for a solid the total energy imparted is split up into three portions, namely (*a*) a quantity absorbed in increasing the external kinetic energy, (*b*) a quantity absorbed in increasing the kinetic energy of rotation relative to the centre, which is presumably absorbed by the electrons in the outer rings, and (*c*) a quantity absorbed in increasing the potential energy of the molecules, i.e. in doing work against the inter-molecular forces. Section 8 discusses the amplitude of molecular vibration. Section 9 proceeds to find the simplest of the elastic constants, viz. compressibility, on the basis of the above assumptions; (10) and (11) deal with Young's modulus and residual rays. Data for copper are given, namely: $2{\cdot}02 \times 10^{-16}$ erg absorbed by each molecule to increase the energy of translational motion, $1{\cdot}2 \times 10^{-16}$ erg absorbed by the rotational motion, and $0{\cdot}76 \times 10^{-16}$ erg absorbed in doing work against the inter-molecular forces.

Part II of the paper re-states the theory for the cubic and face-centred cubic crystals which are the two common arrangements for the solid state. Section 1 deals with the potential energy of displacement; (2) considers amplitude of molecular vibration; (3) evolves an expression for compressibility; (4) applies the theory to face-centred cubic crystals. [The paper is mathematical throughout.] H. H. Ho.

1655. *The Kinetic Theory of Absorption in a Gas.* **G. Ribaud.** (J. de Physique et le Radium, 3. pp. 81–86, March, 1922.)—Lorentz was the first to show that the coefficient of damping, r, introduced by the classical electromagnetic theory in the equation of movement of the absorbing electron, $md^2x/dt^2 + mrdx/dt + mn_0^2x = X_0e$, can be interpreted as due to collisions undergone by the particle which supports the absorbing electron. Lorentz's work, followed by a similar investigation by L. Bloch, explains the presence of the friction term, $mrdx/dt$, and shows that r has the value $t/2$, t being the mean interval between two consecutive collisions of the absorbing molecule with neighbouring molecules. The present author has shown [see Abs. 299 (1922)] that the theory is in excellent accord with experiment, except in the wide continuous absorption bands. The theory has now been extended, however, so as to render it entirely general. The electric field of the wave acting on the absorbing electron has the effect of increasing the K.E. of the molecule which supports the electron. The calculation shows that the K.E. of translation is not changed, but that the K.E. of rotation is modified. It is possible to evaluate the mean gain of energy dW of the molecule between two successive collisions, and it is found that in regions far removed from resonance this energy is independent of t; for resonance it is a maximum, and proportional to t^2. The total energy absorbed by the particle between two collisions, assuming the presence of all possible frequencies in the incident wave, is shown to be $W = \pi X_0^2e^2t/8m$, where X is the amplitude of the wave, e and m the charge and mass respectively of the electron, and t the mean interval between two collisions. This energy does not depend on the particle which supports the electron; it is proportional to the interval between two collisions. A particular case is given where W has the value approximately 4×10^{-16} erg, a number equal to about 1/100th of the K.E. of a molecule at ordinary temperatures. The energy absorbed by a molecule between two consecutive collisions even in the most favourable case (4×10^{-14} for a gas at a pressure 1/100 mm.) is very much less than a quantum. It appears, however, that the energy absorbed by all the molecules in the interior of a mass of gas is not dissipated instantaneously, and it is conceivable that, for a sufficiently intense excitation, certain molecules, after a great number of successive collisions, may accumulate a quantum of energy, and cause the production of light. This may give an explanation of the phenomenon of fluorescence, at least in the case of a gas. T. B.

1656. *The Kinetic Theory of Gases; Sutherland's Constant S and van der Waals' "a" and their Relations to the Intermolecular Field.* **R. H. Fowler.** (Phil. Mag. 43. pp. 785–800, May, 1922.)—It is well known that the constant S introduced by Sutherland into the formula for the viscosity of a gas, and the constant a of van der Waals' or Dieterici's equations of state express the effects of intermolecular attractions. Comparing the equation of state of a gas in the form $pv = \mathrm{N}k\mathrm{T} + f(\mathrm{T})/v + \mathrm{O}(1/v^2)$ with the equation assumed by K. Onnes, $pv = \mathrm{A} + \mathrm{B}/v + \mathrm{C}/v^2 + \mathrm{D}/v^4 + \mathrm{E}/v^6 + \mathrm{F}/v^8$, it is clear that the second "virial coefficient" B of the latter equation is strictly comparable to the calculated $f(\mathrm{T})$ of the former one. Keesom finds that the observed and calculated second virial coefficients for argon can be reconciled on the assumption that the argon atom behaves like a sphere of diam. $\sigma = 3 \cdot 29 \times 10^{-8}$ cm. surrounded by a field of force $\phi(r) = \alpha r^{-5}$ of such intensity that the work $\pi(\sigma)$ done in separating two molecules from contact ($r = \sigma$) to infinity is $1 \cdot 63 \times 10^{-14}$ erg. The values of b (van der Waals) and S (Sutherland's constant) are given by $b = \frac{2}{3}\pi \mathrm{N}\sigma^3$, and by Chapman's corrected formula $\mathrm{S} = 0 \cdot 1956\pi(\sigma)/k$ (inverse 5th-power attractions). The results obtained, however, from compressibility and viscosity data show a striking disagreement, *e.g.*, for argon the value of S obtained from compressibility data is 23·6, and from viscosity data 162; for $b \times 10^3$, similarly, the values obtained are respectively 2·01 and 1·33. The discrepancy is partly explained by the fact that whereas the theoretical formula for the second virial coefficient B is exact, the formula used for the viscosity is only correct so far as the first power of S/T.

Two simple proofs are given of the exact formula for van der Waals' a as a function of the intermolecular field of force. The calculations are reduced to explicit formulæ for two particular molecular models:—(1) Elastic spheres attracting according to an inverse S-th power law; (2) elastic spheres surrounded by a limited spherical shell in which there is a constant attraction, with no forces at all outside. T. B.

1657. *Note on the Theory of Radiation.* **C. G. Darwin.** (Phil. Mag. 43. pp. 641–648, April, 1922.)—The formal connection between the optical and the thermodynamic descriptions of an arbitrary field of radiation is worked out. In optics the primary description is in terms of the electric and magnetic forces, and an arbitrary field is specified by giving those forces at all times and places. In thermodynamics, on the other hand, the analysis is in terms of radiant energy, passing through every point in every direction and sorted out according to its frequency. Thus it is not very easy to find any point of contact in their fundamental definitions and procedure. The only process by which the two types of quantity can be related consists in expressing as integrals the whole flow of energy across an area in terms of both and then identifying the elements of the two integrands. The *modus operandi* consists in the repeated application of Fourier integrals. The most important step in the process is based on a theorem due originally to Stokes, and used for a similar purpose to the present one by Rayleigh (Phil. Mag. 27. p. 460, 1889). The radiation field is specified in the optical manner by means of the six components of electric and magnetic force. The thermodynamic description is derived from these by first expressing the optical quantities as a set of plane waves going in all directions; then the Poynting vector is calculated from these, and integrated so as to give the total flow of energy through a given aperture in a given time. By successive applications of Rayleigh's theorem the result is brought to an integral of the same form as the corresponding thermodynamic expression, and the inter-relation is then given by equating the two integrands. The thermodynamic specification of the field is thus expressed formally in terms of the optical. T. B.

1658. *Latent Heats of Fusion.* I. **[Mrs.] K. Stratton** and **J. R. Partington.** (Phil. Mag. 43. pp. 436–446, March, 1922.)—The latent heats of fusion of benzophenone, phenol, and monoclinic sulphur (8·85 gm. cals. per gm.) have been determined by electrical heating at the melting-point. A theory of fusion from the point of view of the quantum theory, with the use of Debye's formula for the energy, has been suggested. In some cases the existence of intramolecular vibrations, as well as rotations, is shown to be probable in the case of liquid molecules. AUTHORS.

1659. *Molecular Thermodynamics.* **B. A. M. Cavanagh.** (Phil. Mag. 43. pp. 606–636, March, 1922.)—It is shown that on the basis of a *very* broad assumption, a general treatment of the thermodynamics of any system of phases, from the point of view of molecular theory, can be developed. The paper deals with various problems from this viewpoint. L. H. W.

1660. *Heat Distribution on a Radiating Plane.* **K. Aichi.** (Phys. Math. Soc. Japan, Proc. 4. pp. 25–27, March, 1922.)—The temperature V on a radiating plane is determined by the equation $\Delta V = \partial^2 V/\partial x^2 + \partial^2 V/\partial y^2 = k^2 V$ [see Abs. 404 (1920)]. The paper shows how a doubly periodic solution of this equation may be obtained. The paper is mathematical and cannot be usefully abstracted. J. W. T. W.

1661. *Heat Distribution on the Radiating Surface of a Torus.* **K. Aichi.** (Phys. Math. Soc. Japan, Proc. 4. pp. 28–32, March, 1922.)—Obtains, in the form of a series, a solution of the equation expressing this heat distribution. The paper is mathematical and cannot be usefully abstracted. J. W. T. W.

1662. *Relation between Entropy and Probability. Integration of the Entropy Equation.* **G. A. Linhart.** (Am. Chem. Soc., J. 44. pp. 140–142, Jan., 1922.)—The rate of increase of the specific heat with the entropy of a given element or compound depends upon the probability of the randomness of the individual particles. At the absolute zero or at the point of zero kinetic energy it is quite certain that each particle will remain in a fixed position. The probability, therefore, will be unity. At relatively high temperatures the probability of that state prevailing is very nearly zero. Now, the mathematical expression of the above statements may be assumed to be proportional to the term $(C_\infty - C)/C_\infty$, which is unity at absolute zero, and at relatively high temperatures approaches zero. The straight-line equation $C = C_\infty kT^x(kT^x + 1)$ is finally obtained, in which k is the slope and $\log k$ the intercept on the ordinate. This equation expresses, within the probable error, the specific heats of all substances thus far obtained by thermoelectric methods. A table is given showing the results for copper. [Abs. 439 (1907) and 571 (1912) should be consulted.] **H. H. Ho.**

1663. *Adiabatic Liquefaction of Fluids.* **J. Villey.** (Comptes Rendus, 173. pp. 1453–1455, Dec. 27, 1921.)—Bruhat has recently announced two results relating to the refraction of adiabatics [Abs. 952 (1922)], namely :—The heat of vaporisation of a liquid tends towards a limiting value L_0 at absolute zero of temperature, which is not zero; and that, whatever may be the initial state, an adiabatic expansion sufficiently pronounced should always bring about the vicinity of liquefaction and even lead to total liquefaction. Ariès has disputed these two conclusions by arguments based on the limits of validity of the approximations in the thermodynamic equations. The present author now points out that these results are entirely in accord with kinetic theory conceptions, and he deals with each of them in detail. The paper is mainly mathematical. **H. H. Ho.**

SOUND.

1664. *Plane Reflection of Sound as Exhibited by the Pin-Hole Resonator.* **C. Barus.** (Nat. Acad. Sci., Proc. 8. pp. 66–69, April, 1922.)—The pin-hole resonator is a resonator consisting of a parallel pipe open at one end, closed at the other, and at the centre of the plug closing that end is embedded the pin-hole tube which leads away to the manometer. This device is here used to deal with plane oblique reflection of the sound from an organ pipe. Graphs are given showing how the maxima and minima (of the stationary waves formed by reflection) recur in definite sequence. E. H. B.

1665. *Resonance Hypothesis of Audition.* **C. R. G. Cosens** and **H. Hartridge.** (Nature, 109. p. 11, Jan. 5, 1922.)—Long-distance telephony has shown that low-pitched notes travel faster than high-pitched, owing to the impedance of the electrical circuits. Yet the complex sounds of the human voice suffer but small apparent change in quality and distinctness in transmission. This suggests response of the ear to tones, independently of relative phases, in which case true harmonic analysis must occur in Corti's organ. Presumedly, then, the ear must contain resonators. To test this, two electrically driven tuning-forks emitting pure tones with rates of vibration in ratio 1 to 3, as giving the greatest contrast in form of the sound-wave curves, were mounted independently, and the higher toned fork was sounded continuously, the other concurrently at irregular intervals. No difference in the quality of the sound due to the combination was detected, the response of the ear appearing quite independent of the differing relative phases. With two sources containing overtones, however, the ear readily detected differences in the quality of the sound as the relative phases were altered. The authors suggest that the controversy of a good many years ago as to whether or not the ear could detect difference of phase may have arisen from one school having used pure tones free from harmonics, while the other used impure tones containing harmonics. G. W. de T.

1666. *Resonance Theory of Hearing.* **H. Hartridge.** (Nature, 109. p. 76, Jan. 19, 1922.)—This note combats the views of W. Perrett (*ibid.*, 108. p. 569, Dec. 29, 1921) that it was impossible to explain on the resonance theory the hearing of two notes simultaneously of the same pitch but of different quality. The resonance theory, in that it explains the perception of overtones, even when their intensity is small compared with that of the fundamental, also explains how we can tell whether two different instruments are contributing to a tone or one only. But there are other clues, besides that given by overtones, which in accordance with the resonance hypothesis the ear might make use of—namely: (*a*) if there were beats, due to two instruments not being exactly in tune, the observer might infer that two were sounding and not one; (*b*) if the sound waves from one instrument reached the observer's right ear a little earlier (or later) than they reached his left, whereas those from the other instrument had different time relationships, he might infer that there were two sources of sound; and (*c*) if the sounds did not begin and end together, the observer might get information from this also. All these possible methods of observation are compatible with the resonance theory. As an additional new piece of evidence in favour of the resonance theory the author quotes that the *tuning-factor* multiplied by *persistence-factor* for frequencies from 128 to 1024 gives a nearly *constant* product (19·8 to 22·6), which agrees with the theory of Helmholtz. E. H. B.

1667. *Tuning-Fork Damping.* **R. Ll. Jones.** (Phys. Soc., Proc. 34. pp. 66–70, Feb. 15, 1922.)—An examination of the method due to A. Campbell [see Abs. 615 (1919)] of determining the damping decrement of a tuning-fork, in which it is assumed that the amplitudes of the vibrations of a galvanometer are closely proportional to those of the fork which is producing the currents by induction. It is here shown mathematically that the above assumption is legitimate, provided the field concerned is not very irregular. If the field varies uniformly, the effect on the tuned galvanometer is the same as if the field were uniform and its strength the mean of the uniformly varying field, and the decrement of the fork is correctly determined by Campbell's method in these cases. It is only when the rate of change, or slope, of the field changes rapidly within the range of movement concerned that other complications arise and the method may be said to fail. E. H. B.

1668. *Beating Tones of Overblown Organ Pipes.* **V. Lough.** (Phil. Mag. 43. pp. 72–77, Jan., 1922.)—Having collected a number of wooden pipes of the ordinary open-ended type, each pipe was tested separately at various wind pressures, and it was found that instead of jumping suddenly to the octave as generally supposed, in nearly all cases the transition is perfectly gradual, and usually includes an intermediate stage extending over a considerable range of pressure in which regular beats occur before settling down to the regular octave tone. In one case, with very prominent beats, the pipe having a pitch of about 300 per sec. and being voiced for 6–8 cm. of water pressure, quite regular beats of a frequency of 8–10 per sec. were audible over a range of about 11–15 cm. of pressure. The frequency of the beats is nearly constant throughout this range. From the results of analysis by ear with spherical resonators, it seems that the beating (or variation in intensity) takes place mainly in the first and second overtones, the fundamental remaining nearly steady through its gradual decrease. A number of photographic records taken to verify and enlarge these observations are reproduced in the paper. E. H. B.

1669. *Analysis of the Energy Distribution in Speech.* **I. B. Crandall and D. MacKenzie.** (Phys. Rev. 19. pp. 221–232, March, 1922.)—*The frequency distribution of energy in speech* has been determined for six speakers, four men and two women, for a 50-syllable sentence of connected speech, and also for a list of 50 disconnected syllables. The speech was received by a condenser transmitter whose voltage output, amplified 3000-fold, was impressed on the grids of twin single-stage amplifiers. The unmodified output of one of these amplifiers was measured by a thermocouple and was a known function of the total energy received by the transmitter, corrections being made for the slight variation with frequency of the response of the circuit. The output of the other amplifier was limited by a series resonant circuit to a narrow band of frequencies, the energy in this band being measured by a second thermo-couple. The damping of the resonant circuit was so chosen that sufficient resolving power and sufficient energy-sensitiveness were obtained over the range from 75 to 5000 cycles per sec.; and 23 frequency settings were made to cover this range. For each syllable simultaneous readings were recorded on the two thermo-couples at each frequency setting. Corrections were applied to offset the unavoidable variations in total energy incidental to repetition of a given syllable. 13,800 observations were made for all speakers. *The energy distribution curves* obtained are essentially the same for connected as for disconnected speech, and indicate that differences between individuals are more important than variations due to the particular test material chosen. A composite curve drawn from the individual curves shows a great concentration of speech energy in the low frequencies, a result which would not be expected from data previously published by others. The actual results contain a factor due to standing waves between the speaker's mouth and the transmitter, a complication always present in telephoning; this could not be eliminated.

The rate of energy output in speech for the normally modulated voice was determined from the readings for total energy and was found to be about 125 ergs per sec. AUTHORS.

1670. *Radiation of Sound in the Free Atmosphere.* **E. v. Angerer** and **R. Ladenburg.** (Ann. d. Physik, 66. 5. pp. 293–322, Jan. 10, 1922. Engineering, 113. p. 529, April 28, 1922.)—The chief results of these experiments are as follows:—(1) In the immediate neighbourhood of the explosion sound radiates at greater than the ordinary velocities (extending up to 1150 m. per sec.), and then at greater distances asymptotically approaches the normal speed. (2) The speed of sound from a detonation in the free atmosphere, reduced to 0° C. and dry air, is (330·8 ± 0·1) m. per sec. (3) Fog has no influence on the speed of sound. (4) Occasionally, at great distances from the source of sound, secondary sound rays occur which down-wind precede the primary rays by 0·1 to 0·3 sec., but up-wind come later by 0·1 to 0·2 sec. E. H. B.

1671. *Method of Exciting Vibrations in Plates, Membranes, etc., Based on the Bernoulli Principle.* **K. Grant.** (Phys. Soc., Proc. 34. pp. 104–107, April, 1922.)—It is known that a plate placed close to a flanged orifice from which a stream of air or liquid is issuing is attracted towards the orifice. If the plate be mounted as a diaphragm it can be excited to strong vibration by a suitable blast, and a loud sound is produced with high efficiency. AUTHOR.

1672. *Nature of Vowel Sounds.* **R. A. S. Paget.** (Nature, 109. p. 341, March 16, 1922.)—The observations here recorded were made on the author's own voice. The sounds were observed by ear, first for the whispered vowels and then with a larynx note superimposed. In the whispered series it was found that each of the separate vowels was characterised by *two* resonant notes, an upper component (here called "whistle note") ranging from about $\sharp d''$ (608 ∼) to e^{iv} (2579 ∼), and a lower component (here called "resonator note") ranging from $\sharp d'$ (304 ∼) to $\sharp a''$ (912 ∼). The two series are independent of each other, so that, for example, an ascending scale of resonator notes and a descending scale of whistle notes may be produced simultaneously. The characteristic whistle and resonator notes are not absolutely fixed (for an individual voice), but may vary in some cases over as much as five semitones without loss of the vowel characteristic. When a larynx note is added, as in singing or talking, the pitch of the resonator note does not appear to be affected at all by variations of pitch of the larynx note. The whistle notes are generally not affected, so long as their pitches are 2 or 3 octaves from that of the larynx note. As the pitch of the larynx note is further raised towards that of the whistle note, the latter tends to adjust itself or "draw" towards the nearest harmonic of the larynx note which lies within its characteristic range for the vowel in question. E. H. B.

1673. *Beating Tones of Singing Flames.* **D. Banerji.** (Indian Assoc. for Cultivation of Science, Proc. 7. Parts 1 and 2. pp. 47–51, 1921.)—Cyclical forms of vibration in the singing flame which are produced by adjustment of the flame length, so as to be intermediate between the stages when the fundamental on one side, and the octave of the motion on the other, are strongly brought out, have been experimentally studied, and photographs taken are reproduced in the paper. The visible effect of this form of vibration is the throbbing motion of the flame accompanied by beats in the octave. The phenomenon is determined mainly by the size of the flame and its position in the tube. [See Abs. 734 (1914).] E. H. B.

1674. *Vibrations of Pianoforte Strings.* **P. Das.** (Indian Assoc. for Cultivation of Science, Proc. 7. Parts 1 and 2. pp. 13–20, 1921.)—The main features of the vibrations of the pianoforte string were first elucidated by Helmholtz, who assumed that the force exerted by the hammer during impact to be of the form $F \sin pt$. Next Kaufmann discussed it on different lines with the aid of functional solutions of the equation of wave-motion, but his treatment of the case of a string struck near one end was only approximate. Kaufmann's work is here extended so as to give more accurate results by working out the successive functional solutions. A graph is plotted showing the pressure of the hammer, which increases discontinuously by sudden jumps of magnitude $2\rho v_0 c$. The graph bears a close resemblance to those obtained by C. V. Raman and Banerji by a different method [see Abs. 737 (1920)]. E. H. B.

1675. *Amplitude of Vibrations Maintained by Forces of Double Frequency.* **N. C. Krishnaiyar.** (Phil. Mag. 43. pp. 503–510, March, 1922.)—Rayleigh was the first to discuss the theory of the vibration maintained by an influence whose frequency was double that of the vibration maintained. The well-known example of such maintenance is the longitudinal form of Melde's experiment. According to theory first advanced, the phase is constant and independent of the amplitude maintained which is indeterminate. But it is known experimentally [C. V. Raman, Abs. 200 (1913); N. C. Krishnaiyar, Abs. 1459 (1920); R. N. Ghosh, Abs. 492 (1920)] that the phase of the vibration is not independent of the amplitude, and a study of the maintained amplitudes brings out a number of results not indicated by the above theory. In the case of fork maintenance, the wire reacts on the fork and complicates matters. The author found that when an alternating current of 50 cycles, and therefore of 100 *heat* cycles per sec., was passed through a wire whose length and tension were adjusted to a frequency of 50 per sec., the wire on account of the periodic thermal expansion vibrated with a large amplitude. And there was no reaction between the wire and the maintaining influence. The experiments with this show (as indicated by a graph) that there is no max. amplitude for best tuning, and this is supported by the new theory here developed. A number of other points are also brought to light and harmonised with theory. E. H. B.

1676. *Sound-Proof Partitions.* **F. R. Watson.** (Univ. of Illinois, Eng. Experiment Station, Bull. No. 127. [78 pp.] March, 1922. Engineering, 114. pp. 196–197, Aug. 18, 1922.—Abstract.)—An elaborate account of a careful and prolonged treatment of the subject divided into twelve parts or chapters, illustrated by 31 diagrams, graphs, and photographic reproductions, and complete with bibliography. The information was drawn from three sources: theory of sound waves; experimental investigations of the effects of materials on sound; and the behaviour of examples of sound-proof installations. The details, although drawn from these three sources, were found to co-ordinate satisfactorily, and to lead to similar conclusions. Sound may be transmitted from one side of a partition to the other in three ways: it may progress through continuous air passages, it may pass as an elastic wave through the solid structure of the partition; or, by setting the partition in vibration, it may originate sound waves on the other side. Referring to the first way, the sound passes freely if the openings are large, such as the ventilating openings in a partition. If, however, the passages are small in cross-section, as in the case of a porous material, the progress is hindered and a certain amount of absorption of the energy takes place, due to the friction of the air in the sides of the pores. With a partition impervious to air, the direct progress of the waves is interrupted. A thin partition is set in vibration, and thus originates new waves on the far side. For a thicker, more rigid partition, its vibrations are smaller, and a considerable part of the energy is reflected. The transmission in this case takes place by compressional waves communicated to the solid material of the partition. The amount of energy thus transmitted is usually quite small.

In view of these considerations a sound-proof partition should be as rigid and free from air passages as possible. Special attention should be paid to the ventilation system. The absorption of sound is an essential feature for sound-proofing. Reflecting the sound and scattering it is not enough; it must be absorbed, that is, converted into heat energy by friction, before it is eliminated as sound. This means that carpets, draperies, etc. (or even hair felt), should be present. Full details of a number of special cases are given with clear diagrams of the means adopted in each. E. H. B.

1677. *Aeroplane Sounds and Structure of Wind.* **T. Terada.** (Phys. Math. Soc. Japan, Proc. 4. pp. 43–46, March, 1922.)—Puts forward an hypothesis as to periodic fluctuations of wind velocity which, if present, might cause sudden changes in the intensity of the sounds heard from an aeroplane. An actual example of this kind is cited, and the records of wind velocities at the time indicate the probability of the conditions prevailing which would explain the observed phenomena on the author's theory. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1678. *Determination of the Elementary Electrical Quantum from the "Schrot" Effect.* **J. B. Johnson.** (Ann. d. Physik, 67. 2. pp. 154–156, April 27, 1922.)—Schottky [Abs. 332 (1919)] and Hartmann [Abs. 1920 (1921)] have recently published papers on this subject. It is here pointed out that Schottky has apparently made a mistake in the evaluation of a certain integral, with the result that calculation of the elementary electrical quantum ϵ from Hartmann's observations gives a value 500 to 1000 times too small. Using the corrected value of the integral, the value of ϵ is found to be of the right order of magnitude. At high frequencies the value of ϵ is almost correct, while at low frequencies the value is not more than six times too great. A. W.

1679. *Pressure in Magnetised and Polarised Fluids.* **G. Gouy.** (Comptes Rendus, 174. pp. 264–270, Jan. 30, 1922.)—Liénard showed in 1894 that, where P is the normal surface tension on a fluid isolated in space, I the magnetic intensity, making an angle θ with this normal, and μ the magnetic permeability, $P = 2\pi I^2\left\{1/(\mu - 1) + \cos^2\theta\right\} + \text{const.}$ The existence of such a variable pressure constitutes a hydrostatic paradox, but the text-books quote the result without proof, the result being obtained by Liénard, and subsequently by Duhem, in the course of very general and consequently lengthy discussions. The author therefore gives a simple direct proof by equating to zero the work done in the passage of a small thin disc of the fluid along an isothermal and reversible path to a distant reservoir of the same fluid, lying outside the magnetic field, connected with the fluid mass by a long capillary tube so fine as not to affect the field, added to that of replacing the disc by fluid from the reservoir. In the case of a dielectric with polarisation I and specific inductance K, and noting that $I\cos\theta = \sigma'$, where σ' is the density of the imaginary surface layer which would produce the same potential as the actual polarisation, the formula becomes $P = 2\pi I^2/(K - 1) + 2\pi\sigma'^2 + \text{const.}$, so that the term containing θ is simply the electric pressure which would give rise to the fictitious layer σ', so explaining the paradox. Hence for a uniformly polarised, incompressible liquid $P = 2\pi\sigma'^2$ simply. For a gas $K - 1$ is very small, and I^2 of the second order, so that $P = (K - 1)F^2/8\pi + \text{const.}$ The pressure would then be greater within the field F than outside, approximately following Boyle's law, resulting in an *electric compression*, which has been called an *electric contraction*, and attributed to intermolecular forces, and this, the author shows, would contradict the conservation of energy. It is easily shown that, taking P into account, the apparent forces will be K times less in a dielectric than *in vacuo*, so accounting for specific inductance without the old assumption that the real electric forces vary with K, which is irreconcilable with electronic theory.

Errata. (*Ibid.*, p. 504, Feb. 13, 1922.) G. W. de T.

1680. *Orbits in the Field of a Doublet.* **D[orothy] Wrinch.** (Phil. Mag. 43. pp. 993–1014, May, 1922.)—Investigates the two-dimensional motion of a particle in such a field. L. H. W.

1681. *Simplified Proof for the Retarded Potentials and Huyghens' Principle.* **E. H. Kennard.** (Phil. Mag. 43. pp. 1014–1017, May, 1922.)

1682. *Height Variation of the Atmospheric Electric Potential Gradient in the Lowest Layers of the Air.* **H. Norinder.** (Reprint from Sårtyrck No. 1. [96 pp.] Stockholm, 1921.)—The observations described in this paper were made at Upsala, Sweden. Three insulated steel wires, 18 m. long, were stretched at heights of 1, 2, and 3 m. respectively between a pair of vertical posts erected on an expanse of level ground. Collectors were placed at the middle points of the wires, and the p.d.'s recorded by means of self-recording (Benndorf) electrographs in a neighbouring instrument hut. Later, higher levels were reached by a second collector system, consisting of a pair of parallel wires 43 m. long at a fixed vertical distance of 43 cm. apart, stretched between a second pair of posts, and capable of vertical displacement between the ground and a height of 9·5 m. Water-spray collectors were employed at first, but owing to freezing in winter, were abandoned in favour of polonium collectors. The discussion is based on 12 months' observations with the fixed system, omitting cases of marked disturbance by precipitation, fog, etc., and on 125 observation series with the movable system spread over the next 12 months. In summer, on an average, the potential gradient increases with height at least up to 9·5 m., except in a thin layer next to the surface, less than 1 m. thick. In winter it increases with height from the surface up to about 5 m. and then decreases. An increase of potential gradient with height implies a negative volume charge, which is attributed to an excess of heavy negative ions formed by the amassing of light, mobile ions on neutral nuclei. The decrease near the surface in summer, attributed to an outflow of positive ions through earth capillaries, is absent in winter, when the ground is frozen and covered with snow. The presence of ion-absorbing layers is evidently of importance for the height variation in winter, when the charge changes sign at about 5 m. In summer, when convection is more active, this occurs above the region explored. Incidentally, too, it is noted that the potential gradient at Upsala is considerably below the mean for Europe. M. A. G.

DISCHARGE AND OSCILLATIONS.

1683. *On Small Ions of High Mobilities.* **O. Blackwood.** (Phys. Rev. 19. pp. 281–282, March, 1922.)—Nolan has published research [see Abs. 294 (1918) and 473 (1921)] in which he claims to have found ions of very high mobility from spray and from radio-active substances. The present author presents evidence indicating that these results are capable of another interpretation, in which the commonly accepted mobility of the ions holds good. P. E. S.

1684. *Ionisation by Cumulative Action.* **K. T. Compton.** (Phil. Mag. 43. pp. 531–537, March, 1922.)—In a previous paper [Abs. 1470 (1920)] the author summarised some evidence that ionisation in low-voltage arcs cannot be due to effects of single impacts, but must be the cumulative effect of two or more impacts. Additional evidence for this is now presented, and it is concluded that while ionisation by single impact may be of primary importance in producing ionisation in rarefied gases, as in Geissler tubes, ionisation by cumulative action is of preponderating importance in arcs in monatomic gases and vapours. Horton and Miss Davies [Abs. 545 (1922)] have criticised the author's proof of the existence of true ionisation of helium below the ionising potentials as inconclusive on two grounds: (1) the probable photoelectric ionisation of neon or other impurity, and (2) uncertainty regarding the significance of a measured ratio on whose values the conclusions were based. Evidence is now given to prove that these criticisms are unfounded. The work of Horton and Miss Davies proves that radiation may play an even more important rôle in cumulative ionisation than had previously been suggested, being active not only in maintaining atoms in an abnormal state, but also in photoelectrically ionising them when in this condition. It appears to be reasonable to suppose that cumulative ionisation becomes an increasingly important factor in ionisation as conditions become more favourable to cumulative action and less favourable to direct ionisation by single impacts. It would therefore be expected that cumulative action would be particularly important in the temperature ionisation of gases, and therefore that the part played by radiation in promoting temperature ionisation would be very important. An illustration of the possible importance of such a concept of temperature ionisation is seen in the opportunity it affords of explaining certain failures of the theory of ionisation in the solar chromosphere recently proposed by Saha [Abs. 218 (1921)]. This will be dealt with more fully in a subsequent paper. A. W.

1685. *Motion of Electrons in Argon.* **J. S. Townsend** and **V. A. Bailey.** (Phil. Mag. 43. pp. 593–600, March, 1922.)—In a previous paper [Abs. 970 (1922)] the authors gave an account of an investigation of the motion of electrons in nitrogen, hydrogen, and oxygen, and it was shown that the loss of energy of an electron in colliding with a molecule, and the mean free path of the electron, may be found from the experimental determinations of the velocity of the electron in the direction of the electric force, and its velocity of agitation. In the present paper the results are given of a similar investigation with argon, these being of particular interest, as they show that the molecules of this gas are very different from those of the other gases. Thus when an electron moving with a velocity of the order 10^8 cm./sec. collides with a molecule of argon it loses about one ten-thousandth part of its energy, but when it collides with molecules of the other gases it loses more than 1 % of its energy. Also the mean free path of an electron moving with these velocities in argon is about 10 times as long as in other gases at the same pressure. A. B. W.

1686. *Ionisation and Radiation Potentials and the Size of the Atom.* **B. Davis.** (Nat. Acad. Sci., Proc. 8. pp. 61–63, April, 1922.)—Eve has recently published a note on a relation between the ionisation potential and the size of the atom [Abs. 1674 (1921)]. Eve considers that the size of the atom is determined by the radius of the outer electron ring. The author considers that the boundary of the atoms should not correspond exactly with the outer ring, but should extend beyond it If the electron ring were the limit in the solid state it would require no work to remove an electron from an atom in this state. The photoelectric effect shows that work *is* required, and that it is approximately the same as the radiation potential. It is here considered that the limit of the atom is the distance b from the centre that an electron needs to be lifted to produce the radiation potential. If I is the ionising potential and R the radiation potential, it follows that $(I - R)b$, or $(I - R) \times$ (atomic volume)$^{1/3}$, should be a constant. A table is given of the value of this product for a large number of substances, Eve's results for the product $I \times$ (atomic volume)$^{1/3}$ being included. It is seen that degree of constancy of the product $(I - R)V^{1/3}$ (where V = atomic volume) is considerably greater than for the other product. For the inert gases He, Ne, A this is particularly marked. A. W.

1687. *Spectral Distribution and Red Limit of the Photoelectric Effect for Platinum. Dependence on the Gas Content.* **R. Suhrmann.** (Ann. d. Physik, 67. 1. pp. 43–68, April 12, 1922. Extract of Dissertation, Dresden, 1921.)—The research described shows that the effect of occluded gas on the photoelectric properties of Pt depends on the wave-length of the exciting light, the decrease being much greater in the long-wave than in the short-wave region. In the ultra-violet region the decrease due to occluded gas is very small, while for light of wave-length 265 $\mu\mu$ a reduction to about 2 % was observed. [See Abs. 722 (1914).] A. W.

1688. *Sparking Potential in Argon at Reduced Pressures.* **E. R. Stoekle.** (Phys. Rev. 19. pp. 258–259, March, 1922.)—Experiments showed that with an arc between calcium electrodes in argon at 40 mm. pressure the potential required to start an arc decreased to unexpectedly low values after the arc had been allowed to run some time. The author attributes the low sparking potentials observed to the progressive purification of the argon by the Ca vapour formed in the arc discharge. If p is the pressure in mm. of mercury and d the distance apart of the electrodes (also in mm.), when $pd = 7$ a sparking potential of 137 volts was found for the argon purified by the calcium arc. The slightest impurity, such as a tiny air bubble liberated from the mercury of the pressure gauge, produced no observable change in pressure, but produced a marked change in the observed sparking potential. A. W.

1689. *Electrodeless Discharge in Mercury and Cadmium Vapours.* **J. S. van der Lingen.** (Zeits. f. Physik, 8. 3. pp. 145–151, 1922.)—The experiments described by Kowalski [Abs. 1590 (1914)] were repeated, using a highly evacuated quartz tube 10 cm. long and 2 cm. in diam., containing a little mercury. In place of the single ring previously employed a wire spiral was used surrounding the tube, and the spiral was fed from a high-frequency source. At room temperature no discharge took place, but on slightly warming the tube a sudden discharge occurred, and a direct-vision spectroscope showed that most of the light from the discharge was in the yellow region. Increase of temperature changed the character of the discharge, the light appearing to be white with a reddish tinge. Further increase of temperature changed the colour to green, the intensity of which increased at first and then with further increase of temperature gradually faded and finally disappeared. Photographs of the spectra of the three stages are reproduced and described in detail. Further experiments showed that the presence of foreign gases in the discharge tube caused the emission spectrum of mercury to be given at much lower temperatures than with mercury vapour alone. Photographs of the electrodeless discharge in cadmium vapour showed that the distribution of intensity is quite different from that obtained with the cadmium spark discharge, and the spectrum obtained varies with the temperature of the discharge tube. [See also Abs. 136 (1914).] A. W.

1690. *Disappearance of Gas in the Electric Discharge.* IV. **Research Staff of the General Electric Co., London.** (Phil. Mag. 43. pp. 914–937, May, 1922.)—The experiments described are concerned primarily with the disappearance of gas in the presence of phosphorus vapour, and form a continuation of previous work [Abs. 1814 (1921)]. The main experiments were directed to determine how the quantity of gas absorbed in the discharge in the presence of phosphorus varies with different factors. The following conclusions are reached :—(1) *Nature of the Gas.*—Compound gases and some elements are excluded on the ground of chemical change. Of the rest, the inactive gases are little absorbed ; hydrogen and nitrogen, on which the experiments have chiefly been conducted, behave almost identically. (2) *The nature of the discharge* has little direct effect on the amount of gas absorbed. (3) *The form of the vessel* is important only in so far as it affects the area of the walls exposed to the discharge. (4) *The pressure of the gas* during absorption has, within wide limits, no effect on the amount absorbed. (5) The amount of gas absorbed increases with the *amount of phosphorus* present up to a certain point, but varies somewhat according to the state in which the phosphorus is introduced. (6) The state of the walls has no effect within wide limits, but the absorptive power can be greatly increased by "evaporating" certain substances from an electrically heated filament and so depositing them on the walls. Metallic tungsten is among the substances having this property, but no relation has been found generally between this property and others. These substances act to some extent as substitutes for phosphorus.

A general discussion of the results is given, and the view is advanced that the absorption is determined by the formation on the walls of the vessel of electrically polar layers to which ions of the gas adhere in virtue of their charge. The explanation of the action of phosphorus (together with As, and probably S and I) given in previous papers is maintained. A. W.

1691. *Condenser Discharges through a General Gas Circuit.* **C. P. Steinmetz.** (Am. I.E.E., J. 41. pp. 210–223, March, 1922.)—This paper is entirely mathematical, and even the author's abstract of it is too long for reproduction here. It is only possible to reproduce the brief summary given at the conclusion of that abstract, as follows :—The condenser discharge through an inductive circuit of negligible ohmic resistance, but containing a gas circuit, is always oscillatory. The oscillation consists of a finite number of half-waves ; this number is the smaller the greater the energy dissipation in the gas path. The oscillation stops abruptly, leaving a finite voltage and charge in the condenser, which may be in the same or in the opposite direction to the initial voltage.

The frequency of the successive half-waves is not constant, but decreases, that is, the wave-length decreases, in the successive half-waves.

If the potential drop across the gas circuit is constant the discharge consists of pure sine half-waves. In a circuit of negligible ohmic resistance, the successive half-waves decrease by a constant difference. In such a circuit, the discharge becomes non-oscillatory only if in addition to the gas path, it contains an ohmic resistance greater than the critical resistance of the classical equations.

If the potential drop across the gas circuit decreases with increasing current, the discharge waves are cumulative, that is, the current increases during each half-wave, and the decay of the wave is produced by the amplitude of the successive half-waves decreasing at the current reversal, but the exponent of the exponential term is positive. Such a circuit acts like a combination of a constant counter e.m.f. and a negative resistance. The discharge through such a circuit becomes non-oscillatory only if, in addition to the gas circuit, it contains an ohmic resistance greater than the sum of the critical resistance of the classical equations plus the negative resistance of the gas circuit.

The condenser discharge through an inductive circuit containing in addition to an ohmic resistance a gas path, is intermediate between the discharge through a pure gas path and the classical condenser discharge equations, but always retains the characteristics of the discharge through a gas path, of a finite number of half-waves, a residual charge on the condenser, a decrease of the frequency, and a change and often reversal of the attenuation constant. L. H. W.

1692. *Measurements of the Field round an Undamped Oscillator of the Hertz and the Abraham Type.* **L. Bergmann.** (Ann. d. Physik, 67. 1. pp 13–42, April 12, 1922. Dissertation, Giessen.)—Caspar has investigated analytically the distribution of amplitude and phase in the field round a Hertz or an Abraham electric-wave generator (Jahrb. d. drahtl. Tele. 13. p. 221, 1918). In the present paper the author describes an experimental investigation of the same problem. A valve was used to produce continuous oscillations in both cases. The wave-lengths employed were of the order of 2 m. The receiver consisted of two straight rods (whose length could be varied) with a crystal detector interposed, and the latter was joined to a galvanometer, the arrangement being such that the galvanometer deflections were proportional to the square of the electric force. The field was investigated all round the two oscillators used, and the results show fairly good agreement with Caspar's theoretical work. A. W.

1693. *On a Type of Oscillation-Hysteresis in a Simple Triode Generator.* **E. V. Appleton** and **B. van der Pol.** (Phil. Mag. 43. pp. 177–193, Jan., 1922.)—Deals with the "Ziehen" effect of German authors, to which the present authors have given the more applicable term "oscillation hysteresis." The authors summarise as follows:—A general non-linear theory is developed to determine possible and stable amplitudes when the characteristic is given. The conditions necessary for two stable amplitudes are examined, and it is found that for two stable amplitudes, one of which is zero, the expression for the characteristic when developed as a Maclaurin's series must have positive fifth and negative third differential coefficients. Experiments confirming this are described, and it is shown that the relation between the oscillation amplitude and one of the circuit constants is irreversible, so that for certain values the amplitude may be either zero or finite according to the method of approach. It is shown theoretically that an electrical impulse above a limiting value may cause the amplitude to jump from zero to a finite value. This is proved experimentally by use of a transient e.m.f. from a coil and moving bar-magnet. The relations of the critical values for the starting and stopping of oscillations and the maintained electrode potentials are investigated experimentally, and it is found that there is a region of grid potential in which the amplitude is a single-valued function of the circuit constants, so that conditions for starting and stopping are the same. For such values of grid potential the characteristic is approximately represented by a power series of three terms. For other values of grid potential a difference of critical circuit constants is found, with possibility of the hysteresis effect. A power series of five terms for the characteristic accounts for the phenomena. Experiment shows that two stable amplitudes, both differing from zero, are possible, depending upon the seventh differential of the characteristic. B. J. L.

1694. *Oscillation Hysteresis in a Triode Generator with Two Degrees of Freedom.* **B. van der Pol, Jr.** (Phil. Mag. 43. pp. 700–719, April, 1922.)—In the case of two coupled oscillatory circuits, one of which is part of a triode generator, the question arises whether the two possible modes of vibration can exist simultaneously, or, if this is not the case, whether the one or the other mode will obtain for any particular conditions. Experimentally it is found that when the system oscillates in one mode and the natural frequency of the secondary circuit is varied gradually, the system jumps at a certain point from the first mode to the other. If afterwards the variation in the secondary is reversed, the jump to the original frequency takes place at a different point, and thus a kind of oscillation hysteresis is obtained. The present paper gives a mathematical treatment of this subject for the case of two closely coupled circuits. Several theoretical contributions to the problem have already been given [Abs. 1603A and 750B (1921)], but the phenomenon has only been dealt with by means of a linear theory of sustained oscillations. A complete solution cannot be obtained without the introduction of non-linear terms which occur through the curvature of the triode characteristics. In the present paper such non-linear terms are introduced, and experimental data are given which are in agreement with the more complete theory now presented. A. W.

1695. *Effect of Pressure and Gas Content on the Action of Vacuum-Tube Detectors.* **H. A. Brown** and **C. T. Knipp.** (Phys. Rev. 19. pp. 278–280, March, 1922.)—The authors' purpose was to find how the degree of vacuum and the nature of the gas in the tube affect its operation as a detector. The pressure of the gas in the tube was varied, and readings were taken of the anode voltage for the loudest signal response (called the "operating voltage"), and also of the comparative intensity of signal response for various measured pressures. This was done for several tubes of the same type and for tubes of different type and make. Different gases were also used. The results obtained were as follows:—The degree of vacuum in a detector tube is important. A pressure of 0·0025 to 0·005 mm. Hg gives a response two or three times as loud as that for a pressure of 0·05 mm. The operating voltage for the above vacuum is 40 to 50 volts. The adjustments of operating voltage and best filament current are much easier at the above pressures. The operating voltage E is connected with the pressure P by a relation $E = e_i(a)^{1/P}$, where e_i is probably the ionising potential of the gas and a is a constant. For various gases similar curves are obtained. The bend in the curves occurs at the point of best audibility. To the right of the bend (increasing pressure) the adjustments of operating voltage and filament current become critical. Neon, nitrogen, and CO_2 give about the same intensity of response as air. Argon gives a slightly stronger response, helium a slightly weaker one, and the response with hydrogen in the tube is very much weaker. The operating voltage for He-filled tubes is about 30 % higher than for the other gases mentioned above, and is considerably less critical than for these gases. Mercury vapour also gives good results, and has the advantage of requiring only about 16 to 22 volts for best operation. A. W.

1696. *Compensation of Coupling in Oscillating Circuits.* **N. v. Korshenewsky** and **M. Wien.** (Zeits. techn. Physik, 3. 4. pp. 121–123, 1922.)—When working with high-frequency currents, especially if using thermionic tubes, it is almost unavoidable that a certain coupling should establish itself between circuits which should not be coupled, so that disagreeable consequences arise. It is, therefore, useful to de-couple (entkoppeln) or to destroy these couplings. Two methods can be employed for this purpose: (1) the method of derived circuits, and (2) the method of the auxiliary oscillating circuit. The theory of these methods is developed, and an application of the last one to a receiving antenna, allowing of a troubling oscillation being completely offset, is given. E. B.

1697. *Differences between Magnetically- and Electrically-coupled Oscillating Circuits.* **N. v. Korshenewsky.** (Jahrb. d. drahtl. Tele. 19. pp. 94–101, Feb., 1922.)—The comparison between two circuits, coupled either electrostatically or magnetically, is made for the case of forced oscillations by employing the method of calculation of complex quantities. Some results already known are found and made clear. It is interesting to note that magnetic and electric couplings between two circuits cannot compensate or annul each other if resistances are present in the wires of the coupling condensers. E. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1698. *Effect of Tension on the Electrical Resistance of Abnormal Metals.* **P. W. Bridgman.** (Am. Acad., Proc. 57. pp. 41–66, April, 1922.)—The tension coefficient of resistance of Li, Ca, Sn, Sb, Bi, manganin, and therlo has been determined. These substances are all abnormal in that their pressure coefficients of resistance are positive. Young's modulus for these metals has also been determined. The tension coefficient for bismuth and strontium is found to be negative, but positive for the other five. In the discussion the author shows that these coefficients are in accord with his theory of resistance. The conduction mechanism of Li, Ca, Sb, manganin, and therlo is on the whole "transverse," that of bismuth is longitudinal, and that of strontium is a combination.

The negative tension coefficient found by Tomlinson for nickel has been verified for Ni of high purity, and in addition the hysteresis effects and the effect of changes of temperature have been studied. Cobalt, on the other hand, is found to be entirely normal. It is suggested that the explanation of the abnormal behaviour of Ni may be found in a depression by tension of the transition point normally at 360°. **Author.**

1699. *Effect of Pressure on the Resistance of Mercury.* **W. Jaeger and H. v. Steinwehr.** (Zeits. f. Physik, 9. 3. pp. 201–202, 1922. From the Physikal-Techn. Reichsanstalt.)—Describes the results of experiments carried out on a U-tube filled with mercury *in vacuo*, and having a resistance of about half an ohm. Slight alterations in temperature were corrected, but no allowance was made for the effect of pressure changes in the glass containing tube. Pressures from zero to 2 atmos. were used, and the mean apparent change of electrical resistance per atmo. was found to be $3{\cdot}8 \times 10^{-5}$. The correction for the glass tube only affects the second significant figure. The value found is slightly in excess of previous determinations by other observers, who used much wider ranges of pressure variations. It is suggested that the value 4×10^{-5} per atmo. be adopted for the correction of standard resistances. J. W. T. W.

1700. *Variations in Conductivity of Solid Electrolytes.* **P. Vaillant.** (J. de Physique et le Radium, 3. pp. 87–100, March, 1922.)—In view of the irregularity observed in the influence of light on the conductivity of phosphorescent sulphides, particularly calcium sulphide [Abs. 451, 519 (1921)], an investigation has been made of the orders of magnitude and of the duration of the perturbations to which the conductivity is subjected by small changes in the temperature. These perturbations, which are not connected with the phosphorescence, but are observed in the same degree with the non-phosphorescent lead sulphide, are both important and persistent, and when the equilibrium is destroyed by the thermal change, several weeks may elapse before it is restored. The results obtained may, indeed, be regarded as of general applicability, the phenomenon involved being related to the existence of electrolytic conductivity in solids. When a solid electrolyte, in equilibrium at a certain temperature, is subjected to thermal change, its conductivity undergoes two effects which appear to be independent, the one being instantaneous and the other progressive. Towards the first effect the conductivity behaves, as a first approximation, as an exponential function of either the absolute temperature or of its inverse. The progressive effect, which is revealed in a series of oscillations of the conductivity of diminishing amplitude, is initially either an increase or a decrease according as the temperature falls or rises. The rapidity of this increase or decrease in electrical conductivity rises with the extent of the temperature-change, and its connection with the latter indicates the existence of two distinct phenomena, each giving rise to oscillations. T. H. P.

1701. *Anomalous Dielectric Properties of Fused Silica.* **A. Jaquerod and H. Mugeli.** (Arch. des Sciences, 4. pp. 10–26, Jan.–Feb., and pp. 89–119, March–April, 1922.)—The authors review the literature dealing with the anomalous dielectric properties of fused silica, and detail the results of an investigation of such properties. They find that the anomalous current is expressed in terms of the time t by the relation $y(t) = Ae^{-\alpha t} + Be^{-\beta t} + Ce^{-\gamma t}$. The relation $y(t) = Bt^{-n}$ is not satisfied. When the temperature reaches 60° C., a normal conduction current is observed.

This increases rapidly according to the relation $i = Ke^{a\theta}$ as the temperature θ is raised to 100° C. Values are deduced for the specific conductivity of fused silica for temperatures between 0° and 120° C. The values range from $2 \cdot 9 \times 10^{-23}$ mho at 0° to $3 \cdot 3 \times 10^{-17}$ mho at 120° C., per cm.^{2} area and cm. thickness. Curves representing the residual currents of charge and discharge are not usually superposable. It appears, however, that the total quantity of electricity transferred by the anomalous discharging current is equal to that transferred by the anomalous charging current. The amount of charge transferred by the anomalous current is a function of the actual temperature, and depends likewise upon the successive temperatures to which the dielectric has been subjected. Increase of temperature is accompanied by a rapid decrease of the anomalous current. Between 20° and 65° C. the charge transferred can be represented as a function of the temperature θ by the relation $Q = Q_0 e^{-0 \cdot 0765\theta}$. Duration of heating, equally with the temperature to which the dielectric is heated, produces a permanent effect upon the properties of fused silica. Certain capricious phenomena differing from time to time and attributable neither to a temperature effect nor to the influence of radio-active substances are observed in the dielectric. Gases, such as helium and hydrogen, dissolved in the quartz affect the residual phenomena, but such influence is not clearly defined. J. S. G. T.

1702. *Temperature Variation of the Dielectric Constants of Liquids.* **H. Isnardi.** (Zeits. f. Physik, 9. 3. pp. 153–179, 1922.)—The respective values of the dielectric constants and densities of ethyl ether, chloroform, toluene, carbon tetrachloride, benzene, *m*-xylene, and carbon disulphide have been determined for temperatures between − 186° C. and + 106° C. The results, supplemented in some cases by the values obtained by Tangl at higher temperatures, have been employed to test the validity of the formulæ, porposed by Clausius and Mossotti, by Debye, and by Gans respectively, expressing the dielectric constant in terms of the density and absolute temperature of the substance. The Clausius-Mossotti relation expressing $1D.(\epsilon - 1)/(\epsilon + 2)$ as a constant independent of the absolute temperature T, is very closely satisfied by toluene, carbon tetrachloride, benzene, and *m*-xylene in the liquid state, and less accurately by liquid carbon disulphide. The relation is not satisfied by the experimental values obtained for ethyl ether and chloroform. The discrepancy indicates the existence of di-polar molecules possessing a permanent moment in these two cases. The value of the moment can be calculated in accordance with Gans' extension of Debye's theory, and in the case of ethyl ether is found to be $14 \cdot 23 \times 10^{-19}$, agreeing with the value $12 \cdot 7 \times 10^{-19}$ deduced by Lertes [Abs. 1921 (1921)] from the di-polar rotation effect. The molecules of toluene likewise possess permanent moments, but in this case orientation determines only to a very small degree the value of the dielectric constant. The molecules of carbon tetrachloride, benzene, *m*-xylene, and carbon disulphide are not characterised by permanent moments. [See Abs. 196 (1922).] J. S. G. T.

1703. *Resistance of Electrolytes at High Frequencies.* **J. J. Dowling** and **K[atharine] M. Preston.** (Phil. Mag. 43. pp. 537–545, March, 1922.)—Methods of utilising h.f. oscillation valve-circuits for the measurement of resistance have been devised, the principles involved being extensions of the first author's "ultramicrometer" circuits. These methods are capable of great precision and are suitable both for metallic and electrolytic resistances. Preliminary tests indicate that ordinary electrolytes offer the same resistance to h.f. (7 × 10^5 per sec.) currents as to low-frequency currents. L. H. W.

1704. *Dielectric Constants of some of the Esters at Low Temperatures.* **L. C. Jackson.** (Phil. Mag. 43. pp. 481–489, March, 1922.)

1705. *Current in an A.C. Circuit comprising Self-Inductance and a Valve.* **G. Joos.** (Jahrb. d. drahtl. Tele. 19. pp. 109–115, Feb., 1922.)—Papalexi has calculated the behaviour of the current in such a circuit when the valve has a straight-line characteristic [Abs. 688 (1913)]. The author here carries out the calculation for the more general case in practice, when the valve has not a straight-line characteristic. L. H. W.

1706. *Calculation of the Self-Inductance of Square Coils.* **B. Rolf.** (Jahrb. d. drahtl. Tele. 19. pp. 127–129, Feb., 1922.)—Esau [Abs. 639 (1922)] has previously discussed the applicability of a formula given by Niwa and of one given earlier by himself [Abs. 149 (1920)]. Esau has given tables applying to coils in which the number of turns (n) does not exceed 25. The present paper shows how the calculation can be extended so as to apply to larger values of n. A. W.

1707. *The Mutual Inductance between Two Circular Currents.* **D. N. Mallik.** (Phil. Mag. 43. pp. 604–606, March, 1922.)—The mutual inductance M between two circular currents in any relative position is given by

$$M = 4\pi^2 r_1(1-\mu^2)(1-\mu'^2)\sum\left(\frac{r_1}{r_2}\right)^2 \frac{P_n \cos\theta}{n(n+1)} \frac{\partial P_n(\mu)}{\partial\mu} \frac{\partial P_n(\mu')}{\partial\mu'},$$

where r_1 and r_2 are the radii of the concentric spheres of which the circles are the cross-sections, θ is the inclination between the normals to the two circles, and r_1 is less than r_2. When the circles are coplanar $\mu = \mu' = \theta = 0$. Simplified formula are obtained when the wires are close to one another. A. R.

1708. *Effective Capacity of Multi-Layer Coils with Square and Circular Section.* **G. Breit.** (Phil. Mag. 43. pp. 963–992, May, 1922.)—In a previous paper [Abs. 642 (1922)] a formula was given for the effective capacity of coils and applied to single-layer solenoids. In the present paper the same formula is applied to two types of multi-layer coils having a large diameter. It is shown that the average density of volume and surface charge may be obtained in terms of a constant K_e, which depends on the spacing between the turns of the coil and the insulation used. This constant is analogous to the dielectric constant of a homogeneous medium. For a coil having a circular section the formula obtained for the effective capacity is $C_0 = (0{\cdot}08453K_e + 0{\cdot}08230K_0)l$ micromicrofarads, and for a coil with square section $C_0 = (0{\cdot}0886K_e + 0{\cdot}1050K_0)l$, where K_0 is the dielectric constant of the medium outside the coil, K_e the effective dielectric constant of the medium inside the coil, l the perimeter of a single turn passing through the centre of the cross-section. In both cases the diam. of the coil is to be taken as large in comparison with the max. dimension of the cross-section; the winding is assumed to be close, the number of turns large, and the coil itself is taken to be insulated from all objects except the tuning condenser. A. W.

1709. *Representation of Alternating-Current Curves.* **W. Geyger.** (Phys. Zeits. 23. pp. 153–154, April 1, 1922.)—The method described makes use of a straight vacuum tube, the light from which is projected on to the convex surface of a drum whose contour consists of two Archimedian spirals connected by portions of the same diameter. The drum is driven by a synchronous motor fed from the same source as the vacuum tube, and hence a representation of the wave-form is obtained on the screen in rectangular coordinates. [See Abs. 1128 (1915) and Abs. 1002 (1922).] A. W.

1710. *Measurement of Capacity and of Large Resistances by Means of Intermittent Valve Generators.* **S. Rschewkin and B. Wwedensky.** (Phys. Zeits. 23. pp. 150–153, April 1, 1922.)—If a simple valve generator has a condenser, in parallel with a high resistance, inserted in the grid lead, the oscillations become intermittent, a series of groups being obtained separated by silent intervals of greater or less duration [Abs. 137 (1921)]. If the generator frequency is above audible limits a click is heard in the coupled telephone circuit at the beginning and end of each group of oscillations. Theory is given showing how the frequency of intermittence depends on the circuit constants, and a method is described by which measurements may be made of the values of capacities and high resistances. A. W.

1711. *Limit of Sensitiveness of a String Galvanometer.* **J. K. A. W. Salomonson.** (K. Akad. Amsterdam, Proc. 23. 4. pp. 613–615, 1921.)—The controlling force in a string galvanometer is not only the elasticity of the string, but also the force of gravity, and in a very thin filament this latter force preponderates over the former, since it is a function of d^{-2}, while the elastic force is a function of d^{-4}. To obtain a true result the two forces should be combined in the final formula. The author obtains an expression for the value of the diameter d when the two effects are equal in magnitude, and he gives the values of d with strings of different lengths for a number of filament materials. J. W. T. W.

1712. *Application of Thermionic Tubes to High-Frequency Measurements.* **F. Trautwein.** (Zeits. techn. Physik, 3. 4. pp. 123–127, 1922. Comm. from the Telegraphentechn. Reichsamt.)—Some methods of using thermionic tubes for high-frequency measurements are schematically set forth in this article. The following quantities can be measured: Voltage; mean and r.m.s. values of a.c. curves; form factor; amplitude; phase differences; and power. E. B.

1713. *Moving-Coil Galvanometer of High Sensitivity.* **F. Zernike.** (K. Akad. Amsterdam, Proc. 24. 6 and 7. pp. 239–245, 1922.)—The theory of the moving-coil galvanometer is considered in this paper, and it is shown how to make a reflecting type instrument as sensitive as possible. The conditions for max. sensitivity are $K/K_0 = r/r_0 = H/H_0$, where K = total moment of inertia, K_0 = moment of inertia of coil alone, r = total resistance, r_0 = resistance of coil, H = intensity of magnetic field, H_0 = smallest value of H for which motion is aperiodic. By using a quartz fibre suspension and extremely thin electrolytically-deposited silver strips, hanging loosely on either side of the fibre to produce the resisting torque, a sensitivity of 21 mm. per microvolt can be obtained at a scale distance of 1 m. N. W. M.

1714. *New High-Frequency Vibration Galvanometer.* **L. V. King.** (Roy. Soc. Canada, Trans. 15. Sect. 3. p. 143, 1921.)—By means of a mechanical device, the vibrations of the reed of a Brown telephone receiver are optically magnified to such an extent that 1000-cycle alternating currents of a few microamps. may be easily measured. In combination with vacuum amplifiers, currents several thousand times smaller may also be measured. AUTHOR.

1715. *A Valve Amplifier for Amplifying Direct Current.* **H. A. Snow.** (Optical Soc. of America, J. 6. pp. 186–192, March, 1922.)—Two resistance-coupled amplifier circuits were constructed to amplify both a direct and alternating current of 10 mA to 110 to 200 mA magnitude, and tests made to determine the amplification for best adjustments of the circuit constants. AUTHOR.

1716. *Discharge Tube for Demonstration of the Stark-Effect.* **E. Gehrcke.** (Zeits. techn. Physik, 3. 3. pp. 93–94, 1922.)—The discharge tube here described is of spherical form with projecting side tubes for the anode and kathode. The anode is a short cylindrical metal rod. The kathode disc has a slit in the middle, through which canal rays pass. This canal-ray beam passes between two metal plates, each of nearly semicircular section, which are fitted in the side tube behind the kathode. One of these plates (A) is attached to the kathode, the other (B) being insulated. Leads are brought through the glass walls from both the plates A and B. The discharge tube is filled with hydrogen at such a pressure as to give as bright as possible a reddish-white beam of canal rays. The anode and kathode are connected to an induction coil with an ordinary hammer break, and a switch enables the plate B to be connected either to the kathode or the anode. The most suitable line for observation is H_β, a powerful 3-prism spectroscope being used. When the plate B is connected to the kathode, the canal-ray beam passes through a force-free space, and only the ordinary hydrogen lines are observed; but when B is connected to the anode, the field between the plates A and B acting on the canal-ray beam renders the Stark-effect visible. The phenomenon is best seen in the direction perpendicular to the direction of the canal rays. If the discharge tube gets too hard the introduction of fresh hydrogen at once puts it right again. A. W.

1717. *Apparatus for the Measurement of the Thomson-Effect.* **H. R. Nettleton.** (Phys. Soc., Proc. 34. pp. 77–85, with Disc., April, 1922.)

ALTERNATING CURRENTS AND MAGNETISM.

1718. *Intrinsic Field of a Magnet; Relation of its Magnetic to its Electric and Thermal Properties.* **J. R. Ashworth.** (Phil. Mag. 43. pp. 401–419, March, 1922.)—From the ferromagnetic equation, based as it is on a kinetic theory of magnetism, we find that a magnet possesses an intrinsic field, and that this field must be in magnitude immense if energy effects are taken into account, but only very small if the effects of an external applied field are considered. In short, when the intensity of magnetisation is treated as a function of the temperature the intrinsic field must be very large, and when treated as a function of the applied field the intrinsic field must be very small—results which are not consistent with one another. Further, we find from the effects of an alternating field upon ferro-magnetism—more definitely its ability to lower the critical temperature and at the same time its inability to alter the temperature at which electrical resistivity, thermoelectric power, and specific heat change abruptly—that the intrinsic field cannot be regarded as simply and solely a *magnetic* field of immense magnitude.

This and other difficulties disappear if the intrinsic field is treated as the combination of two fields, one a molecular field and the other a true magnetic field; the former in magnitude very large and the latter relatively small. It is then assumed that thermal action operates directly on the molecular field by giving rise to translatory movements of the molecules, and that it only indirectly affects the magnetic field by producing rotational vibrations *through the mutual magnetic forces of the molecular magnets*, the rotational movements so developed being a transcription of the translational movements; on the other hand, orientations of the molecular magnets which result from the application of an external magnetic field cannot appreciably influence translations or displacements of the molecules. AUTHOR.

1719. *Discontinuities of Magnetisation.* **P. Weiss** and **G. Ribaud.** (J. de Physique et le Radium, 3. pp. 74–80, March, 1922.)—Barkhausen has shown that when a ferromagnetic substance is subjected to a continuously increasing magnetic field, noises are produced which may be heard by connecting an amplifier to a coil surrounding the substance in question [Abs. **443** (1920)]. The present paper describes experiments with various substances (magnetite, invar, etc.), and also discusses the subject from a theoretical standpoint. [See also Abs. **1180** (1922).]

A. W.

1720. *Deviations of Liquid Oxygen from Curie's Law.* **W. H. Keesom.** (K. Akad. Amsterdam, Proc. 23. 8. pp. 1127–1136, 1922.)—The magnetic susceptibility χ of gaseous oxygen follows Curie's law, viz., $\chi T =$ constant; but for liquid oxygen the relation holds: $\chi(T + \Delta) =$ constant, where $\Delta = 71$. Onnes considered it possible that the occurrence of Δ in the equation was caused by what is left, in taking the statistic mean, from a directing action of the couples exerted by the oxygen molecules on each other when, in a magnetic field, the molecules come very near to each other. The paper shows mathematically that, very probably, the above view is incorrect. G. E. A.

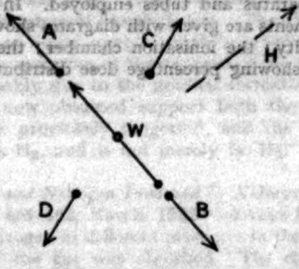
1721. *Magnetic Susceptibilities.* **S. R. Williams.** (Science, 54. pp. 339–348, Oct. 14, 1921. Paper read before a joint meeting of the Am. Phys. Soc. and Am. Assoc. for Adv. of Science.)—An exposition of the present state of the theories of magnetism. Curie's long series of investigations was followed by Langevin's electron theory of dia- and paramagnetism, which has been extended to ferromagnetism by Weiss, Curie's work seemed to indicate that paramagnetic substances would have infinite susceptibility at absolute zero, but recent work has weakened the foundation on which Langevin and Weiss built their theories, and it is all too apparent that the phenomena of magnetism are exceedingly complicated. From the standpoint of the theory, diamagnetism must be almost a universal property of matter, but the diamagnetism of hydrogen is difficult to explain by Langevin's theory. Weiss associates, with the turning of the elementary magnets, something which acts like an extra magnetic field, but which is neither magnetic nor electrostatic. A theory to be comprehensive must explain all magnetic phenomena, but present magnetic theories do not explain magnetostrictive effects. A suggestion by Poynting and Thomson has led to the view that many of the magnetostrictive effects may be explained as being due to the orientation of elementary magnets whose dimensions vary in different directions. The spacing of the atoms also seems to play a very important part in magnetic phenomena. Perrier and Onnes found that the specific magnetisation coefficient of oxygen becomes considerably greater in proportion as the concentration of the oxygen diminishes; Heusler's alloy is also instanced in this connection. In concluding as to the origin of the property of susceptibility, it is stated that in addition to electronic orbits, there must be given to the positive nucleus of the atom a property of induction just as Ewing had in his elementary magnets, and, for ferromagnetic substances at least, these nuclei ought to have different dimensions in different directions, capable of being rotated by means of an external field.

G. E. A.

1722. *Models of Ferromagnetic Induction.* **J. A. Ewing.** (Roy. Soc. Edinburgh. Proc. 42. 1. pp. 97–128, 1921–1922. Nature, 109. pp. 321–322, March 9, 1922.)—The first part of the paper comprises a study, theoretical and experimental, of the field intensity required to cause rupture or instability of a row of similar pivoted magnets. The conclusions were applied to a solitary pair of magnets, for which the field to produce rupture, H_γ, could be expressed as $F_r m/8r^2$, where m is the pole strength, r the distance between the centres of the magnets, and F_r a factor depending on the pole distance, deflection, and angle between field and line of centres of magnets. The magnets used were of the Robison type, and the field was that set up by current within a pair of Helmholtz coils of diam. 49 cm. From an investigation of the behaviour when the field is increased and then reversed, it is concluded that a model consisting simply of rows of pivoted magnets fails quantitatively to represent what happens when a ferromagnetic substance is magnetised. From consideration of the atomic magnetisation of iron, taking the centred cube as the space-lattice, with two atoms in each unit cube, each atom containing a Weber magnetic element, the calculated field in soft iron required to break up the rows is more than a million times as great as the field which actually suffices to make the Weber elements become unstable when the metal is magnetised. A new model has therefore been devised by the author, based on the idea that the system of electrons in each atom comprises two groups: an inner group which constitutes the Weber element possessing magnetic moment and capable of turning in response to an applied field; and an outer group or shell which is to be regarded as held more or less completely fixed relative to neighbouring atoms when the atom is part of a solid body. The outer group of electrons acts on the inner group or Weber element like a number of fixed directing magnets. Models are made in one of which the Weber element is represented by an octet of poles pivoted on a vertical needle, the pivot being situated at the centre of a cube in the corners of which eight magnets are fixed with their lengths pointing to the central pivot. The properties of the model are described in so far as it throws light on the effects of stress, of impurity, of extreme æolotropy such as Weiss found in pyrrhotite. The model also serves to illustrate the mechanical possibility of a collision between an electron and a ferromagnetic atom, which involves no scattering of energy except under quantum conditions. It receives energy in quanta and gives out corresponding quanta of radiation. G. E. A.

1723. *Effect of Magnetic Fields on the Resistivity of some Alloys.* **J. Obata.** (Electrotechnical Laborat. Tokyo, Researches, No. 101. [20 pp.] Dec., 1921.)—The application of the electron theory to electric conduction in pure metals when subjected to a transverse magnetic field shows that the relative change in resistance is made up of two terms, one due to change in molecular configuration, the other due to electronic drift. The latter term is absent in the expression for the longitudinal field. In the case of alloys, the term depending on molecular configuration would be further influenced by a magnetic field. The alloys investigated include constantan, manganin, eureka, platinoid, Cu-Mn, Cu-Mn-Al, phosphor-bronze, Pt-Ir, and nichrome, and the change of resistance was measured in both longitudinal and transverse fields (up to 20,000 c.g.s. units) and at various temperatures between that of liquid air and steam. The resistance determinations could be made in the most favourable cases to 1 part in 1,000,000, and tests on Ni, Au, and Cu were in substantial agreement with those of previous observers. In copper alloys, containing Ni or Mn, both transverse and longitudinal fields diminish the resistance, and the effect observed always decreases with rise of temperature. It would appear that in these cases the field produces an increase in the free path of the conducting electron. For weak fields the decrease is proportional to the square of the field. In phosphor-bronze and Pt-Ir the effect is very small, and is probably due to the presence of magnetic constituents. In nichrome the effects are very similar to those for pure Ni, and, in the opinion of the author, some part of the Ni exists in the free state in this alloy. L. L.

1724. *The Atomic Process in Ferromagnetic Induction.* **J. A. Ewing.** (Roy. Soc., Proc. 100. pp. 449–460, Feb. 1, 1922. Phil. Mag. 43. pp. 493–503, March, 1922.)—In this paper the author suggests modifications of his well-known molecular theory of magnetism to make it conform more closely with modern ideas of the nature of magnetism. The ultimate magnetic particles of the older theory are no longer to be termed molecular magnets, but to be regarded as attributes of the atom. In the Ewing model, control of the deflected magnet was due to the mutual action of neighbouring magnets. This is not entirely satisfactory. The reversible part of the magnetisation curve, which is only a small fraction of the whole, can be realised by grouping the magnets, so that when in alignment neighbouring poles are very near. The range of stability is large, however, and what is required is a narrow range of stable deflection without excessive stability. This may be attained by the arrangement depicted in the Fig. The pivoted magnet W is controlled by two pairs of fixed magnets AB, CD. The components of each pair point in opposite directions, and one component of each is supposed slightly stronger or nearer to the pivoted magnet than the other. Such an arrangement combines small limiting stable deflection with easy rupture of stability. It is then shown how such a model may have its parallel in the atom. The structure assumed is that proposed by A. W. Hull for the Fe atom. Two electrons, on opposite sides of the nucleus, form a doublet, and the remaining 24 are grouped in octets, further from the nucleus, along the diagonals of a cube. The octets make up the fixed magnetic elements AB, CD, the doublet in the interior corresponds to W. Asymmetry of effects of the fixed magnets might be due to their slight displacement or to mutual inductive effects. It might also be set up by the action of neighbouring atoms. Stress and vibration would primarily influence the outer system, the action on the inner element would be secondary. The arrangement described would be suitable if the diameters of the electronic orbits were small in relation to the size of the atom. For large electron orbits a model



is suggested in which the element W is replaced by a coil carrying a current and turning about an axis. Control is obtained by two pairs of fixed coils arranged in transverse planes but exercising a differential effect on the turning coil. L. L.

1725. *Magnetic Storm, May* 13–16, 1921. **G. Angenheister.** (Terrest. Magn. 26. pp. 116–119, Sept., 1921.)—This storm is the greatest recorded at Samoa, and the only one during which aurora has been observed there. In an earlier paper the author has tried to show that great magnetic storms exhibit, during intervals of several years, a 30-day periodicity (29·97 according to A. Schmidt), and the time of the present storm considered with others during the spot-maximum 1915–1921 agrees with this. It is thought that the centres of disturbance responsible for such storms are situated in the deeper layers of the sun, whereas the 27-day period shown by small disturbances and quiet times from one rotation to the next is attributed to the higher and more movable layers.

The Aurora Australis was seen on May 15th (Greenwich date) during max. intensity, extending up to 20° above the horizon in the direction of the magnetic meridian. At a point 8° south of Samoa it was also seen to southward, from which it is deduced that the max. height of the aurora exceeded 400 km. A probable height is given as 1000 km. It is shown that this aurora cannot be accounted for by α- or β-rays on Störmer's theory. M. A. G.

1726. *Completion of the General Magnetic Survey of Australia by the Carnegie Institution of Washington.* **E. Kidson.** (Roy. Soc. Tasmania, Proc. pp. 84–98, 1921.)

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

1727. *Deep Therapy with Röntgen Rays.* **F. Bergter.** (Zeits. techn. Physik, 3. 1. pp. 7–14, and 3. 3. pp. 78–82, 1922.)—For the use of X-rays in medicine, wave-lengths of the order of magnitude from 0·01 to 10 Å. have to be taken into consideration. For deep radiation the wave-length is limited to those smaller than 2 Å. On the basis of the Planck-Einstein formula there exists between the wave-length $\lambda_{\text{min.}}$ and the generating tension the following relationship: $V \cdot \lambda_{\text{min.}} = 12{\cdot}3$ when V in kilovolts and λ in Ångstrom units are measured. This connection is shown by a curve in the present paper; where the properties of different elements appear as functions of the wave-length λ. In the first paper a theoretical discussion of the subject is given, together with an explanation with diagrams of the apparatus and tubes employed. In the second paper details of the experiments are given with diagrams showing the apparatus for measuring intensity; the ionisation chamber; the absorption curve in Al; and a chart showing percentage dose distribution in the human body.
A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1728. *Triatomic Hydrogen.* II. **G. L. Wendt and R. S. Landauer.** (Am. Chem. Soc., J. 44. pp. 510–521, March, 1922.)—Triatomic hydrogen [Abs. 147 (1921)] has now been prepared by three new methods: by means of the Siemens glass tube ozoniser, the Tesla h.f. discharge, and thermionic emission, but attempts to show its presence in hydrogen produced in the nascent condition from solutions of hydrogen ions have been unsuccessful. Such triatomic hydrogen is decomposed catalytically by finely-divided Pt, Ni, Cu, Rb, Sb, and Cd, but it is not affected by contact with Ag, Hg, Sn, Bi, Mo, Zn, or Al. Contraction in volume occurs when this hydrogen is produced by the electric discharge at a pressure of 3 cm., this being particularly marked at the temperatures of liquid ammonia and solid CO_2. It is condensed to the liquid form by exposure to the temperature of liquid oxygen. The spectrum of hydrogen at the temperature of liquid oxygen exhibits progressive intensification of the secondary line spectrum at the expense of the primary series spectrum, which is probably due to the gradual formation of this triatomic form. The results now obtained support both the mechanism of the formation of hyzone previously suggested, and the view that the new gas has the formula H_3, and is not merely iso-H_2. T. H. P.

1729. *Hydrogen and Nitrogen Produced by X-Rays.* **F. H. Newman.** (Phil. Mag. 43. pp. 455–462, March, 1922.)—α-rays from polonium were allowed to act on nitrogen at different pressures in the presence of various elements. Some of the gas was absorbed. The elements tested were sodium, potassium, sulphur, phosphorus, iodine, magnesium, arsenic, mercury, together with the alloy of sodium and potassium. Similar experiments with hydrogen gave absorption with sulphur, phosphorus, and iodine. The absorption of the gas was shown to be due to chemical action resulting in the production of nitrides and hydrides. The chemical activity of the gas is due to an active modification produced by the α-rays. The active form, probably consisting of neutral atoms and triatomic molecules, is not due directly to the presence of ions. The α-rays are the only ones effective from radio-active bodies. AUTHOR.

1730. *Passage of Hydrogen and Helium through Silica Tubes.* **J. B. Ferguson and G. A. Williams.** (Roy. Soc. Canada, Trans. 15. Sect. 3. p. 51, 1921.)—The rate at which hydrogen passes through transparent (not devitrified) silica-glass tubes at 440° C. is $1 \cdot 5 \times 10^{-4}$ cm.^{3} (0°, 760 mm.) per hour per cm.^{2}, the external pressure being 1 atmo. and the internal pressure a few hundredths of a mm. At 628°, 5×10^{-4} cm.^{3}, and at 727°, 8×10^{-4} cm.^{3}. For external pressures of 0·5 to 1 atmo, the rate is proportional to the pressure difference; for 0·25 atmo. the rate is somewhat greater than this relation would lead one to expect. Pyrex glass and (German) combustion tubing were impermeable; the pyrex blackened. Helium at 632° diffused through the silica-glass at least five times as rapidly as hydrogen. Air does not pass at temperatures up to 800° and pressures up to 1 atmo. AUTHOR.

1731. *Linear Relations in the Periodic System.* **W. Biltz.** (Zeits. Elektrochem. 28. pp. 65–70, Feb. 1, 1922. Paper read at Deut. Bunsen-Gesell., Jena, Sept., 1921.)—The *atomic volumes* of the rare gases Ar, Kr, and X, are related linearly to those of the neighbouring halogens: Atomic volume of halogen = 0·5015 × (atomic volume of the neighbouring rare gas), the accuracy of this relation being greater than 1 %. Linear relationships hold also between the atomic volumes of Ar, Kr, and X and those of K, Rb, and Cs; Si, Ge, and Sn; and Ti, Zr, and Ce. The remaining groups of elements show no similar relation, and the lighter elements, F, Ne, and Na, also form exceptions. Similarly the *boiling-points* of Cl, Br, and I are related to those of Ar, Kr, and X according to the expression: boiling-point of the halogen = 2·753 × (boiling-point of rare gas) − 1·8°, the agreement being to within a few tenths of a degree; here, too, fluorine finds no place. Such a relation is lacking with the boiling-points of the alkali metals, and it is pointed out that the boiling of a metal comprises a process differing essentially from that of a non-metal, volatilisation of a metal being accompanied by a change of state indicated by the loss of metallic conductivity. With the critical temperatures a similar linear relationship exists, those of He, Ar, Kr, and X being thus related to those of H, Cl, Br, and I. The same is the case with the atomic refractions, the values for He, Ar, Kr, and X bearing a linear relationship to those (1) of H, Cl, Br, and I; (2) of S, Se, and Te; (3) K, Rb, and Cs. Thus, from the physical point of view, hydrogen undoubtedly belongs to the halogen group. Further, the *atomic radii* of the rare gases are related linearly to those of the elements of the sulphur and alkali metal groups, and in this instance the relationship is extended to Ne, F, and Na. These linear relationships between the atomic properties explain those which have been observed between the molecular properties. T. H. P.

1732. *Application of the Electron Theory of Chemistry to Solids.* **J. J. Thomson.** (Phil. Mag. 43. pp. 721–757, April, 1922.)—A theory of the structure of solids is given based on the views as to the nature of the structure of the atom and the mechanism of chemical combination given in previous papers. Since the atom of a monovalent element has one disposable electron, that of a divalent element two, and so on, there must in a crystal of a monovalent element be such an arrangement of electrons and atoms that for each atom there is one electron, in a crystal of a divalent atom there must be two electrons for each atom, and so on. It is shown that this condition determines the crystallographic forms in which the various elements can crystallise, and leads to a conception of the structure of crystalline solids which allows us to calculate without further assumptions the values of certain physical constants such as the bulk modulus, the value of the critical frequency, and the dielectric constants. The values of these are calculated for elements of different valencies, and are found to agree closely with those found by experiment. AUTHOR.

1733. *Double and Triple Bonds, and Electron Structures in Unsaturated Molecules.* **E. D. Eastman.** (Am. Chem. Soc., J. 44. pp. 438–451, March, 1922.)—A conception of multiple bonds is here presented which is based on the Lewis theory of molecular structure and valency [Abs. 946 (1916); 760 (1920)]. It is suggested that multiple bonding involves the transfer of two electrons from the inner to the outer shell in one or both of two adjacent atomic nuclei, the group of eight being preserved about each, with two jointly-held electrons constituting the bond. This hypothesis is sufficient to explain the restricted region of the periodic system in which elements characterised by multiple bond formation occur. To meet requirements imposed by the facts relating to stability, reactivity, and free rotation, the electrons of unsaturated octets are assumed to be held in equilibrium positions at greater distances from the nucleus than in the ordinary case, the transfer from the extended position to the usual ones liberating energy. No attractive force between electrons is assumed, and the electron arrangement is taken as cubic, although subject to distortion.

On this basis a mechanism is developed for reactions of addition and condensation, such subjects as conjugation, the structure and substitution reactions of benzene, and tautomeric shifting of double bonds being considered. T. H. P.

1734. *Attempt to Separate Isotopes of Chlorine.* **H. Hartley, A. O. Ponder, E. J. Bowen,** and **T. R. Merton.** (Phil. Mag. 43. pp. 430–435, March, 1922.)—Aston's observations indicate that ordinary chlorine consists of a mixture of the isotopes Cl_{35} and Cl_{37} in the ratio of 3 : 1 nearly. In the gaseous condition chlorine will thus consist, on probability considerations, of the molecules $Cl_{35}Cl_{35}$, $Cl_{35}Cl_{37}$, and $Cl_{37}Cl_{37}$ in the ratio 9 : 6 : 1. If we suppose that white light traverses a column of chlorine of such a length that the radiation absorbed by $Cl_{37}Cl_{37}$ is reduced in intensity by a factor 10^{-9}, the corresponding factors in the case of $Cl_{35}Cl_{37}$ and $Cl_{35}Cl_{35}$ will be 10^{-18} and 10^{-27} respectively. If, now, the light after passing through this column of chlorine enters a vessel containing a mixture of H and Cl, which combine under the influence of the light absorbed by the Cl, it would appear to follow that the initial rates of reaction for the molecules $Cl_{35}Cl_{35}$, $Cl_{35}Cl_{37}$, and $Cl_{37}Cl_{37}$ should be in the ratio $1 : 10^{9} : 10^{24}$, provided that the molecules which absorb energy react at a rate proportional to the energy which they absorb, and that the absorption bands do not overlap. Under these conditions the HCl which is formed should consist almost entirely of HCl_{37}, provided the reaction is allowed to proceed for a suitable period. Within the limits of experimental error the results indicate that no separation of isotopes was obtained by the method indicated above. The authors suggest possible secondary reactions which might account for this negative result. A. B. W.

1735. *Separation of the Isotopes of Mercury.* **J. N. Bronsted** and **G. Hevesy.** (Phil. Mag. 43. pp. 34–49, Jan., 1922.)—The hypothesis that isotopy, hitherto found only within the domain of the radio-active elements, may be finally proved to be a general property of matter, has been established by Aston's experiments [Abs. 213, 809, and 994 (1920); 447 (1921)]. The question of the separation of isotopes, already much discussed in radio-chemistry, has consequently become a matter of still more general importance. The authors have already published results [see Abs. 364 (1921) and 447 (1921)] of some experiments on the separation of isotopes, and the present paper contains a more detailed description of the principles and methods, together with the results of further investigation. The results are summarised as follows:—(1) A partial separation of the isotopes of mercury based on the two following methods has proved successful: (a) Evaporation method ("ideal distillation") based on the difference in the evaporation *velocities* of isotopes. The distillate was found richer, the remainder poorer in the lighter isotope, than the initial substance. (*b*) Effusion method. A fraction of the mercury vapour penetrates through narrow openings into the condensation space, where the lighter isotope is found in a relatively larger amount than in ordinary mercury. (2) The results of the experiments agree with the theory in which the evaporation—as well as the effusion velocity of the isotopes—is inversely proportional to the square root of their molecular weights; they are, further, in conformity with Aston's results obtained by means of his mass-spectrograph. (3) The partial separation achieved was proved by density measurements. The density difference between the heaviest and lightest mercury amounts to 0·49 %, corresponding to a difference of 0·1 unit in the atomic weight of mercury. A. B. W.

1736. *Theory of Adsorption Processes.* **A. Eucken.** (Zeits. Elektrochem. 28. pp. 6–16, Jan. 1, 1922. Paper read at Deut. Bunsen Gesell., Jena, Sept., 1921.)—In positive adsorption a gas or a dissolved substance is held by the surface of a (generally solid) substance; the theory has to determine the adsorption forces. The phenomena are of varied types, and the author deals particularly with the adsorption of gases by charcoal, glass, mica, and with the researches of Langmuir, J. F. Homfray, Berenyi, and Polanyi. Charcoal holds argon and oxygen with equal force; the forces are physical, and the phenomena reversible. Platinum, on the other hand, binds only certain gases; there is no real equilibrium and no reversibility. The adsorption-isothermals express the quantity of gas adsorbed as function of the gas pressure or concentration; at sedimentation-equilibrium the attractive force in each layer is equal to the opposing thermal force. H. B.

1737. *Genesis of Elements.* **M. C. Neuburger.** (Phys. Zeits. 23. pp. 133–136, March 15, 1922.)—The author proposes various schematic arrangements of the elements, based on recent observations by Aston and Rutherford on isotopic elements. A. B. W.

1738. *Photochemistry of Silver Compounds.* **F. Weigert.** (Preuss. Akad. Wiss. Berlin, Ber. 39. pp. 641–650, 1921.)—Experiments were made by the author and W. Schöller with the gelatine emulsion (on glass plates) of Valenta, which contains AgCl and also soluble silver salts (nitrate, citrate, tartrate), the ratio of soluble to insoluble silver salts being 2·6 : 1, and with printing-out paper. The very small amount of reduced silver in the latter (a few thousands of a mgm. per cm.^{2}) is eliminated by the nephelometric method of Richards and Wells; the soluble silver is titrated, and a König-Martens spectrophotometer used. It is found that in the emulsion the soluble silver salts practically account for all the reduced silver; the chloride darkens very slowly. The plates are exposed for up to 4 hours to the light of a uviol lamp filtered through cobalt glass. The silver–time curve is S-shaped; at first the silver reduced increases more rapidly than the exposure, and there is a threshold value of the light needed for reduction; the silver reduced acts as autosensitiser. This is utilised in the printing-out process; when the negative is removed after having produced a faint image, the image becomes more intense in yellow light. This, however, is only possible in the presence of soluble silver salts, as is proved by experiments with plates half covered with the emulsion, and half with the emulsion deprived of its soluble silver by washing with water. These experiments also show that the reduced silver becomes less sensitive to red, but more sensitive to light of shorter wave-lengths (absorption-displacement). In the energy measurements a quartz mercury-lamp and a Lummer-Kurlbaum bolometer were used; the light is filtered through water, a solution of quinine sulphate in diluted sulphuric acid, and cobalt glass. These experiments confirm the assumption that only the reduced silver is sensitive, and Einstein's law holds, when the energy absorbed is referred to that silver, and not to the whole of the silver, that would be the first confirmation of the law of equivalence for solid substances. The conclusion drawn with respect to the printing-out process is that silver chloride is itself not sensitive to light, nor does it appreciably supply the reduced silver of the photographic positive. The sensitive material is the metallic colloidal silver originally present in the unexposed emulsion only as an impurity. Hence the colour change is slow first and then rapid, owing to spontaneous acceleration, and slows down again because the photochemical yield diminishes in the solid system as the amount of silver becomes smaller. As the system is solid, the effect is probably due to electrons and not to collision. The action of the chloride seems to be morphological, and connected with the formation of micellæ. H. B.

1739. *Decomposition of Ozone by Light of the Visible Spectrum.* **R. O. Griffith** and **W. J. Shutt.** (Chem. Soc., J. 119. pp. 1948–1959, Dec., 1921.)—According to Weigert ozone is decomposed not only by ultra-violet light, but, in the presence of chlorine, also by blue and violet rays. The author shows that even longer, yellow and red rays are active. The ozone is prepared after Fischer and Massenez, i.e. by the electrolysis of dilute sulphuric acid with water-cooled Pt anodes at high anodic current density. The ozone is collected in a glass tube, 1·8 cm. in diam., 40 cm. high, standing in a thermostat. In order to avoid all deozonisation in the dark (Warburg), all dust particles were excluded. The beam of an arc lamp was reflected down the ozone tube after having passed through a layer of water, two stout plates of crown glass, and a double convex lens. On exposure of the ozone to the light the pressure increased first rapidly for 15 seconds, then slowly; on cutting off the light the pressure fell in 4 mins. to a constant value. This slight effect was due to the absorption of heat rays, which raised the tube temperature by about 0·5 deg. There might be a higher temperature in the ozone near the centre of the tube, but the bimolecular reaction $2O_3 \rightarrow 3O_2$ (Warburg, etc.) did not appear to take place; the slight heating would, therefore, not be the cause of the decomposition. By means of a Hilger quartz spectrograph it was ascertained that no rays shorter than 330 $\mu\mu$ could have entered, so that the active rays seemed to lie between 400 and 780 $\mu\mu$. Further, to limit the range, gelatine-film filters of Kodak, Ltd., were used. It was then found that rays of the extreme red with the head of the band lying between 670 and 760 $\mu\mu$, and, again, rays between 615 and 510 $\mu\mu$, can decompose ozone; the intermediate range .670 to 615 $\mu\mu$ seemed to be inactive. H. B.

1740. *Energy Relations in Photochemical Processes in Gases.* **E. Warburg.** (Zeits. Elektrochem. 27. pp. 133–142, April 1, 1921. From the Reichsanstalt.)—The paper is divided into sections. In the first the apparatus used in these and previous researches are further described. The second section describes the method adopted to obtain reliable results in spite of the inconstancy of the spark intensity, with special regard to the generation of ozone. It would appear that for the ozonisation of oxygen by light of $\lambda = 0{\cdot}207\,\mu$ the law of equivalence holds more exactly than some previous experiments indicated, for pressures up to 100 kg./cm.^{2}; as regards $\lambda = 0{\cdot}253\,\mu$ the accord is less satisfactory. In the third section the author comments upon Stern and Vollmer's views of the photochemical equivalent from the Bohr-Einstein conception of light absorption; the author cannot agree that he is not justified in regarding the splitting-up of molecules as a primary photochemical process. The fourth section deals with the length of the modification period of chlorine in the action of light upon H-Cl mixtures according to Vollmer and to Bodenstein and Taylor (1916). The last section discusses the relations between chemical effects of radiations and the effects of the silent discharge on gases. Assuming the chemical effects of a silent discharge to be due mainly to ionic collisions, the author suggests that the effects on gaseous molecules are about the same, whether the energy be received by radiation or by ionic shock, and that the chemical effects of the silent discharge are closely related to the photochemical effects. H. B.

1741. *Photochemical Reaction between Hydrogen and Chlorine and its Variation with the Light Intensity.* **E. C. C. Baly** and **W. F. Barker.** (Chem. Soc. J., Trans. 119. pp. 653–664, May, 1921.)—The deviations from Einstein's equivalence law may be due to re-absorption by the surrounding reactant molecules of the energy radiated during the reaction [Baly, Abs. 1287 (1920)]. If A and B are the reactant and resultant molecules, and E is the light energy absorbed, then $A + E = B + E + K$. When the reaction $A \longrightarrow B$ is endothermic, K will be negative, $(E + K)$ small, and Einstein's law is likely to be obeyed. When the reaction is exothermic, the re-absorption will depend upon two factors, the concentration of the reactant molecules and the intensity of the activating light. The authors investigate this latter point with mixtures of H and Cl in the presence of water, the source of light being a Pointolite lamp of 500 c.p.; the light intensity is varied by the aid of two nicols. The reaction velocity first follows the law, and then increases more and more rapidly. When the light is temporarily cut off and then re-admitted, the initial velocity is greater than it was before. At the highest intensity complete re-absorption and explosive reaction are approached. The gas expansion produced by ultra-violet radiations during these reactions, moreover, is proportional to the rate of the reaction, and not to the light intensity; the expansion is due to the ultra-violet rays; it takes place when the infra-red rays are filtered off, but not when the ultra-violet are cut off. The conclusions as to re-absorption agree with Slade and Higson's experiments on photographic plates [see Abs. 422 and 853 (1921)]. The results indicate that the frequencies characteristic of the HCl molecule are exact multiples of the fundamental frequencies of the H atom and of the Cl atom; the true molecular frequency should then be the least common integral multiple of the atomic frequencies, and that product can have physical significance only (Norman Campbell) if all the atomic and molecular energy quanta be integral multiples of the fundamental quantum. A new type of photo-catalysis by the light absorbed, not by the reactants, but by the photo-catalyst, is also indicated: the photo-catalyst must contain the same elementary atoms as the reactants. Such a case has been observed by Daniels and Johnston (Amer. Chem. Soc., J. 43. p. 72, Jan., 1921). H. B.

1742. *Decomposition of Hydrogen Peroxide by Ultra-Violet Light.* **G[ertrude] Kornfeld.** (Zeits. wiss. Phot. 21. pp. 66–92, Oct., 1921.)—While partly agreeing with the conclusions of Henri and Wurmser, Tian, Matthews and Curtis, that Einstein's equivalence law does not hold, as often interpreted, the author finds by her experiments and arguments that the law could not be expected to hold, since the decomposition of H_2O_2 is not merely a primary light effect. She suggests that the oxygen atom split off is charged with energy, and that of the atoms of the ionised water molecule formed, the H ions are also charged with energy. Hydrogen was not found in the decomposition products. H. B.

1743. *Photochemical Studies.* XIV. *Fundamental Photochemical Laws.* **J. Plotnikow.** (Zeits. wiss. Phot. 21. pp. 134–140, Feb., 1922.)—A critique of Einstein's law of equivalence and of its advocacy by Weigert. According to the author's view of Einstein's law the energy Q absorbed by a molecule should be, at wave-lengths 800, 100, 1, 0·001 $\mu\mu$ respectively, 35, 279, 3×10^4 and 3×10^7 Cals., and rise asymptotically to infinite values. In reality the intensity of the photochemical effect rises with increasing frequency, but falls off beyond the ultra-violet, and of the many photochemical reactions studied only the photolyses of HI and HBr really agree with Einstein. H. B.

1744. *The Negative Hydrogen Ion of Lithium Hydride.* **A. Klemenc.** (Zeits. Elektrochem. 27. pp. 470–474, Oct. 1, 1921.)—In LiH the hydrogen seems to have taken up an electron, and it should behave like a halogen. Let the model of this ion H' be a hydrogen nucleus about which 2 electrons rotate in the same circle. The energy of rotation would be $E = 3e^2/4r^2 = mr\omega^2$, and the energy difference between the neutral atom and the negative ion, H' would be $\delta = N_R h/8n^2$, where N_R is Rydberg's number. The energy which must be expended to bring an electron up to the neutral gramme-atom would then be $\Delta = 39{\cdot}4$ Cals./n^2, so that $H + e + 39{\cdot}4$ Cals. $= H'$. This Δ can be calculated from thermal data (specific heat, energy of dissociation of molecular hydrogen, ionisation energy of lithium) and the lattice energy of Born. The elaborate calculation yields $13 \pm 2{\cdot}8$ Cals. instead of 39·4 Cals. It had been assumed that $n = 1$. If, however, $n = 2$, then Δ should be 9·8 Cals., which would fairly agree with the calculation. That $n = 2$ would mean that in the formation of LiH, the hydrogen atom takes up an electron in such a way that both the electrons rotate in the second (not the first) Bohr orbit. This is tentatively suggested. In any case the hydrogen would not follow the analogy of the halogen; the formation of halogen ions from atoms and electrons is exothermic, that of the hydrogen ion is endothermic. H. B.

1745. *Isomorphy and Ionic Structure.* **H. G. Grimm.** (Zeits. Elektrochem. 28. pp. 75–81, Feb. 1, 1922. Paper read before the Deut. Bunsen Ges., Jena, Sept., 1921.)—Assuming atomic structures on the lines of Kossel and of Lewis, and the ions in crystals to be held together by electrostatic forces after Born and Landé, the author discusses the question how the ions must be built up to account for their crystal isomorphy, and what constitutes chemical analogy. The shell radius increases as we pass from neon to argon, krypton and xenon, but not in equal steps. When the ions are of similar structure (with 8 external electrons) the isomorphy-relations depend upon the characteristic steps in the ionic radii. Hence oxygen stands apart from S, Se, Te, as Na stands apart from K, Rb, Cs, and Li from Na, and H from Li. Chemical analogy of isomorphous elements will exist for ions of equal numbers of external electrons when the ionic radii are similar, and for ions of different numbers of external electrons when these differences in the number of electrons are approximately balanced by the differences in the radii. H. B.

1746. *Optical Sensibilisation.* III. *Zinc Oxides.* **C. Winther.** (Zeits. wiss. Phot. 21. 7 and 8. pp. 141–167, April, 1922.)—Eibner observed in 1911 that many fast colouring matters, inorganic and organic, were bleached by light when mixed with zinc oxide and gum, especially under glass. P. E. Raaschou found that some common colouring matters like lead white and cadmium yellow were blackened by light when mixed with zinc oxide and glycerine. The author continues these experiments, using zinc oxide with media of glycerine, ethylene glycol, and oxalate, and various colouring matters on glass covered with quartz glass or fluorspar, exposed to daylight and quartz-mercury light, or aluminium sparks. The curves for the different media frequently crossed, that is, oxalate might have the strongest effect for the first 5 mins., and glycerine after 15 mins. Both zinc oxide-glycerine and lead-white glycerines alone were not affected by daylight (though they were blackened by the quartz mercury-lamp), but they were discoloured when mixed. Other lead compounds and mercury salts were also blackened. Eosin and cyanin are more rapidly bleached in the presence of zinc oxide, fuchsin is not. The zinc oxide is not affected chemically, nor is the electric conductivity of zinc oxide-glycerine; in photochemical cells the illuminated zinc oxide plate becomes negative. The sensibilisation is not connected with the visible luminescence of zinc oxide, and the effect is confined to a spectral range in which there is selective absorption, but no sensitiveness to light.

IV. *Ozone Formation in the Presence of Zinc Oxide* (*ibid.*, pp. 168–174, 1922).—Experiments on the discolouration of potassium-iodide paper by ultra-violet rays in the presence of zinc oxide. The reaction was not prevented by moist air, $BiNO_3$, $AgNO_3$, HgCl; it was stopped by water, PbO, HgO, Bi_2O_3, alcohol, acetone, glycerine, etc.

V. *Possibility of Optical Sensibilisation* (*ibid.*, pp. 175–185, 1922).—The phenomena are very complicated. In the case of zinc oxide the effect is ascribed to a dark invisible radiation; the zinc oxide itself remains chemically unchanged when acting as photo-catalyst. The less sensitive a process is with respect to a certain wave-length, the more amenable it is to optical sensibilisation for this radiation. Thus, when compounds of Pb, Hg, Ag, etc., mixed with glycerin, water, or alcohol, are themselves scarcely sensitive, the effect of the zinc oxide is strong, and vice versa. H. B.

1747. *Ionic Equilibrium at Metallic Surfaces.* **H. v. Euler.** (Zeits. Elektrochem. 28. pp. 2–6, Jan. 1, 1922. Paper read at Deut. Bunsen Gesell., Jena, Sept., 1921.)—Experiments made in the first instance on the concentration changes taking place in diluted solutions of silver nitrate in contact with silver. To ensure a large surface, the metal was used in powder form, grains of silver of 0·8 to 0·6 μ being prepared chemically, 1 gm. of which would have a surface of about 1 sq. m. The maximum value of the sorption (increased salt concentration at the surface) was found to be 0·35 milli-ion per m.^{2}. Similarly KCl and silver gave 0·5 milli-ion per m.^{2}. Experiments were then made with gold powder and with gold foil (neither pure), and with mercury-drop electrodes (after Krüger and Palmaer). The sorption did not make the $AgNO_3$ or KCl acid. The discussion concerns the double-layer theory. According to Nernst a metal can give up ions to a solution containing that metallic ion. When, however, silver nitrate solution flows through silver tubes, the potential difference must not be calculated after Nernst, because there is also an electrokinetic potential difference (Freundlich and Rona); the sorbed salt is in the layer which adheres to the metal, so that two solutions of different concentrations glide past one another. The experiments were made by Hedelius and Zimmerlund. H. B.

1748. *Corrosion Patterns on Cold-worked Tin and Zinc.* **H. S. Rawdon, A. I. Krynitsky, and J. F. T. Berliner.** (Chem. and Met. Eng. 26. pp. 212–213, Feb. 1, 1922.)—Gives the effects of deep etching on samples of high-grade tin rolled to a thin strip and annealed at 150° C. for 2½ hours. Acidified alcoholic solutions of stannous chloride were the corroding solutions used, and the attack was distinctly more severe along the grain boundaries than in the interior of the grains. After attack, even for a period of 87 days, the metal appeared to retain its initial ductility. Some of the specimens exhibited a peculiar etching pattern during corrosion, which was independent of and superimposed upon the granular or crystal structural pattern, and appeared to be related to the rolling that the material had received. In the case of zinc, rolled sheet was annealed at 350° C. for 3½ hours and corroded with acidified zinc sulphate solutions. The attack of the metal appeared to be intercrystalline in nature, but no indication was obtained by bending that the metal had been embrittled or otherwise seriously affected in its properties, as in the case of lead after corrosion under similar conditions. C. O. B.

1749. *Manufacture of High-Speed and Tungsten Steels.* **J. W. Weitzenkorn.** (Chem. and Met. Eng. 26. pp. 504–508, March 15, 1922.)—Gives some results obtained by the study of segregation in high-speed and tungsten steels, and shows that the addition of tungsten as ferro-tungsten is better than as metallic tungsten. The results of the analysis of massive carbides separated from steels by suspension in nitric acid are also given; these show that from a steel of composition C 1·34, Mn 0·34, P 0·02, Si 0·59, Cr 3·14, W 15·88, V 0·83 %, the composition of the eutectiform carbides separated and examined was C 3·10, W 55·90, Cr 3·31, V 1·52, Fe 36·17, whilst the composition of the primary austenite was C 0·77, Cr 3·10, V 0·63, W 3·71. These eutectiform carbides are essential factors in imparting high-speed properties and produce a coarse, fibrous, woody structure in the annealed, natural, or hardened states. These conditions cause the steel to be difficult to anneal, to possess hard and soft spots after annealing, etc., and are favoured by high casting temperature and slow cooling. They are best broken up by a combination of mechanical work and heat treatment, as hardening and annealing alone are insufficient. C. O. B.

1750. *Recrystallisation Studies.* **H. A. Holz.** (Chem. and Met. Eng. 26. pp. 580–581, March 29, 1922.)—The author points out the value of three-dimensional "recrystallisation diagrams," in which percentage deformation in previous cold work, annealing temperatures, and grain size are shown. After the recrystallisation diagram of a metal or alloy is once worked out, it is possible to determine the degree of cold work a metal had previously undergone by heating it to a certain temperature and measuring the grain size. In the same way the annealing temperature can be deduced from the grain size, by heating the metal to increasing temperatures until the grain size increases. Recrystallisation studies have also been used in investigating the depth of penetration of work in the case of static and impact hardness-tests. J. L. H.

1751. *Recrystallisation Produced by Annealing.* **P. Gaubert.** (Comptes Rendus, 173. pp. 1089–1092, Nov. 28, 1921.)—The behaviour of vanillin crystals sublimed and examined with polarised light under various conditions of reheating is described with a view to the explanation, by analogy, of the phenomena exhibited by the annealing of metals. Similarly, substances possessing malleable crystals, *e.g.*, paraffin wax, beeswax, are chosen and studied as analogues of worked metals.

A. B. C. L.

1752. *Coalescence of Cementite in Steels.* **A. Portevin** and **V. Bernard.** (Rev. de Mét. 18. pp. 729–751, Nov., 1921. Engineering, 113. pp. 28–31, Jan. 6, and pp. 59–62, Jan. 13, 1922.)—*Theoretical.*—Coalescence is a general phenomenon in all alloys, and consists of particles of the same phase joining up to form larger masses. In steels the cementite passes from the lamellar to the globular form. In the case of hypereutectic steels, it is necessary to consider :—(*a*) coalescence which takes place between *Acm* and A1, and (*b*) coalescence which takes place below A1. In any particular steel the most important factors to consider in dealing with coalescence are (*a*) above A1 :—1. Rate of cooling. 2. Temperature and duration of initial heating. 3. Oscillations of temperature, especially in the neighbourhood of A1. (*b*) Below A1 :—1. Temperature and length of time at that temperature. 2. Preliminary working. 3. Initial fineness of the cementite. Slowness of cooling above A1 causes greater coalescence. This is also true below A1, but to a negligible extent. Heating above *Acm* checks the formation of globular pearlite ; the higher the temperature the more efficacious it is. Temperature oscillation about A1 is the most favourable way of producing coalescence. Opinions appear to be divided as to the effect of the temperature and duration of heating below A1, but there is no doubt that any form of treatment which causes a breaking up of the pearlite, such as work, or the existence of a naturally fine-grained pearlite, is very efficacious as an aid to coalescence. A eutectoid steel shows the least tendency to coalesce, other things being equal, and the addition of a small amount of W or Cr also tends to reduce coalescence ; larger quantities of these elements, on the other hand, tend to render the cementite completely globular.

Practical Considerations.—While the majority of steels can be rendered sufficiently soft for machining by a heat treatment which leaves the pearlite in the lamellar, or even in the sorbitic, form, certain special steels require the cementite to be reduced to the globular form to acquire the necessary softness. Coalescence of the cementite increases the deformability of the metal. This is valuable in such operations as stamping sheet or drawing tubes. It is very much more difficult to get globular pearlite into solution than is the case with lamellar pearlite. This is of extreme importance in the case of material to be quenched, as it renders necessary a considerable increase of the time for which coalesced-cementite steel must be heated before quenching. To study these effects samples of a 0·98 % carbon steel were treated so as to produce, in the one case a globular, and in the other case a lamellar, pearlite. Specimens from each of these samples were heated at 800° C. in a lead bath for varying times and then quenched, after which they were examined in various ways. Some of the results were as follows :—*Microstructure.*—Cementite was still visible in small quantities in the coalesced specimen after 4 quenchings, while it had disappeared completely after the second quench in the other specimen. *Resistivity.*—In both cases the resistivity increased with successive quenching, but the increase is greater in the case of the steel which had an initial globular structure. *Magnetic Tests.*—The magnetic intensity and remanence were greater in the case of the originally globular steel. J. L. H.

1753. *Effect of Sulphur and Oxides on Steel.* **W. J. Priestley.** (Am. Inst. Mining Eng., Trans. [15 pp.] Dec., 1921.)—Gives the results of tests on steels of similar analysis except for sulphur and phosphorus, made in open-hearth furnaces, and made in similar furnaces but refined in basic electric furnaces. The effect of sulphide and oxide inclusions is dealt with, and it is shown that when these are small in amount as obtained by refining in the electric furnace, the reduction of area and elongation have higher values. The method of manufacture of steel at the U.S. Naval Ordnance Plant is described, in which the pig and scrap are first worked in a basic open-hearth furnace and the steel produced is transferred to an electric furnace for refining. Analyses of the various products are given, and a description of the reactions taking place during the refining operation. The steel produced is more uniform, more homogeneous, and more dense than open-hearth steel. C. O. B.

1754. *Hardness of High-Speed Steel.* **A. H. d'Arcambal.** (Chem. and Met. Eng. 25. pp. 1168–1173, Dec. 28, 1921.)—Gives the results obtained by the microscope and by hardness tests, physical tests, and cutting tests during an investigation of the effects of different hardening treatments on 12 samples of high-speed steel. Eleven of these samples contained Cr, V, and W, the Cr varying from 3·33 to 4·70, the V from 0·26 to 1·75, and the W from 12·65 to 19·05; the twelfth was a Co-Mo steel containing 5·25 Co and 4·90 Mo. The results indicate that the greatest degree of secondary hardness obtained by tempering and the highest actual red-hardness are obtained in specimens given the highest quenching temperature, 1260° C. Micrographs show that partial austenisation has taken place in the steel given this high quenching temperature, with almost complete solution of the carbides and tungstides not in massive or envelope formation. When quenched from 1260° C. and drawn at 600°, the scleroscope hardness is as great as, and sometimes greater than, in the undrawn condition ; during the drawing, austenite is converted into martensite. Toughness and cutting efficiency have been increased from 100 to 200 % by the 600° C. draw. Cutters, given a high quenching temperature and drawn at 427° C. fail quicker than when given a 232° C. draw. High-speed steel quenched into a bath at 600° C., then cooled from that temperature and not drawn, does not possess the same good qualities as when drawn to 600° after quenching. High-speed steel in the larger-size rounds is very seldom free from segregations of massive cementite, and these do not go into solution on hardening. Tools made of this material are inferior in quality owing to brittleness and deficiency in red-hardness. The scleroscope or Brinell hardness of a high-speed steel is no indication of its cutting qualities. Some of the cutters which showed the greatest cutting efficiency and some of the cutters which produced very little work gave the same hardness readings. The file test is also a misleading one, because a steel may be easily filed with a good file and yet do as good work as a similar steel which is file-hard. C. O. B.

1755. *Artificial Seasoning of Steels.* **H. J. French.** (Chem. and Met. Eng. 25. pp. 155–158, July 27, 1921.)—Dimensional changes with time are often encountered in hardened reference gauges, and their magnitude and occurrence vary considerably in gauges made from the same material under similar conditions of manufacture. The results are given of a systematic investigation of the effects of seasoning gauge blocks on five steels which were annealed, machined, and ground into rough gauges, hardened by heating in a lead bath, quenched in oil, ground, seasoned in various ways, and finished in accordance with the Hoke method. Details of the composition, hardening, seasoning treatments, and dimensional changes and Shore hardness numbers are given. Short gauges, $\frac{1}{8}$ in., showed no appreciable changes in length with or without seasoning over a period of seven months, and lengths of about 6 or 8 in. are recommended for studying length changes with time. Plain carbon steel appears to be the least desirable from the standpoint of permanence. The heat treatment recommended as a result of the work, consists of 10 to 80 alternate 5-minute dips in oil at 200° and ice water; these treatments are the most generally effective for obtaining permanence. C. O. B.

1756. *X-Ray Data on Martensite Formed from Austenite.* **E. C. Bain.** (Chem. and Met. Eng. 26. pp. 543–545, March 22, 1922.)—Gives a short description of Hull's method of crystal analysis and the use of X-rays for estimating grain size [see Abs. 242 (1922)]. The results of examination of a sample of steel originally examined in 1920 and found to consist of coarse austenite are described. After being kept at ordinary room temperature for 15 months this same specimen was examined in the X-ray spectrometer and gave the normal spectrogram of ferrite, quite different from that of fine-grained austenite. Tests with a magnet indicated that the austenite was very largely transformed; and obviously the period of 15 months had been sufficient to convert the austenite into martensite at ordinary temperatures. At a magnification of 4½ diams. there was apparently no change in the structure. On deeply etching the transformed specimen and examining at 100 diams., discontinuities of etching figures appear within the original well-marked grains; whilst these configurations can hardly represent the new grain size of martensite, they do show that the region within the grain is a complex. Martensite was found to possess an apparent grain size somewhat larger than that of a truly coarse-grained tungsten ingot which yields a pattern characteristic of a very fine-grained metal. The old grain boundaries do not enclose single orientations, but crystal fragments resulting from the allotropic transformation of γ into α iron. C. O. B.

1757. *Hardness Variations in Heat-Treated Steel.* **C. R. Hayward.** (Chem. and Met. Eng. 25. pp. 695–696, Oct. 12, 1921.)—Shows that the centre of a heat-treated bar of steel is with rare exceptions harder than the material nearer the edge. The results of experiments consisting of quenching medium carbon steels from 850° and reheating to 300° or 400° for various lengths of time are given; these show a decided difference in scleroscope hardness of the centre and places nearer the edge. In the case of a tool-steel containing 0·9 % carbon the same difference is noted, but is not so marked as in the case of medium carbon steel. It is suggested that the probable explanation is to be found in one of the strain theories of hardness. All steel on cooling is subjected to internal strains varying in intensity with the rate of cooling; even a steel very slowly cooled is subject to a small amount of this strain. Once hardening by slip or interference in grain growth is produced, varying from centre to outside, it is impossible to eradicate it completely. At drawing temperatures near the critical range, equalisation is approached; if, however, it is ever attained during heating, a slight differentiation takes place again on cooling. C. O. B.

1758. *Influence of Bismuth on Bronzes.* **J. Czochralski.** (Zeits. f. Metallkunde, 14. pp. 70–72, Feb., 1922.)—Experiments as with Pb, Sb, As on the effect on the mechanical properties of a bronze (86 Cu, 9 Sn, 5 Zn) produced by the addition of increasing proportions of bismuth (up to 2 per cent.). Tensile strength, elongation, hardness, and torsional and impact strength decrease markedly. But the bad effects do not show so long as the Bi is kept below 0·1 %, which is advantageous for casting and machining the alloy. Up to 0·1 % of Bi might therefore be permissible. H. B.

1759. *Alloys of Tellurium with Lead and with Antimony.* **M. Dreifuss.** (Zeits. Elektrochem. 28. pp. 100–101, Feb. 1, 1922.)—Tellurium is fused and the metal is added in small portions. Part of the Te goes into the slag, reducing the lead so that the lead surface remains bright even at red glow; a small percentage of the Te is taken up by the Pb; a good deal is lost by burning. Since Te and Sb alloy in all proportions, the author tried to introduce Te into lead with the aid of this alloy, by fusing antimony, stirring tellurium into it, and adding lead or Sn-Pb. There is hardly any gain as to hardness and compression strength, however; alloys of Pb-Sb (12 per cent. of Sb) containing 5 or 6 per cent. of Sn had better mechanical properties than the much more expensive alloys containing 2 per cent. of Te. H. B.

1760. *Recrystallisation of Deformed Aluminium.* **E. Rassow** and **L. Velde.** (Zeits. f. Metallkunde, 13. p. 557, Dec., 1921.)—Cubes of 10 mm. edge were cut out of an Al of 98·5 % (rest iron and silicon), compressed to 5, 25, 50, 75 %, and reheated to 200, 250, 300, 350, 400, 500, 600° C., for about half an hour. The sample was then cut at right angles to the direction of the compression, and the surface was etched with HF of 10 per cent. and with concentrated HCl. The grain size, 1 67 mm.

diameter, was decreased, the diminution in the diameter setting in at a certain temperature. When the compression had been slight, this temperature was a little above 400°; with the highest compression the change took place below 300°; the lowest grain size observed was 0·04 mm. These observations are in agreement with the rule of Czochralski-Heyn, that the inferior crystallisation limit lies the lower, the greater the cold work. The figures of Carpenter and Elam, who observed recrystallisation in pure Al at 250° with a compression of 97·3 per cent., would fit into the curves.

E. Rassow. (*Ibid.*, p. 558, Dec., 1921.)—In these experiments the specimens were rolled so as to produce the same compression as above. The results obtained were practically the same, and Masing's statement that two kinds of stress do not have the same effect when their sequence is reversed, especially when the second stress is small, was hardly confirmed. H. B.

1761. *Segregation in Alloys.* **O. Bauer and H. Arndt.** (Zeits f. Metallkunde, 13. pp. 497–506, Nov., and pp. 559–564, Dec., 1921.)—When a fused alloy of Bi-Pb is slowly cooled, the Bi (density 9·8) and Pb (13·34) separate more or less according to their density. To prevent this "block-segregation," the melt should be cooled rapidly. The conditions are different when mixed crystals are formed. With slow cooling there should neither be block-segregation nor "inter-crystalline segregation" (finally leading to the former), because the mixed crystals are always richer in the constituent of higher melting-point than is the liquid with which the crystal is in equilibrium. In this case, then, rapid cooling should favour segregation. The authors experiment with alloys of Cu-Sn, Cu-Mn, Cu-Ni, Hg-Pb, Al-Zn, Al-Cu, Ag-Cu, Au-Cu, Au-Ag, Fe-C, Cu-Zn. The ingots are inverted truncated cones or pyramids, the moulds cubes of cast iron, preheated or cooled in some cases. The results of the many analyses of samples from different parts of the ingots are little in accord with expectations. A strong fall in temperature from the ingot edge to the core and rapid cooling favoured in most cases segregation, but the block segregation was "inverted," not normal (except with Au-Ag and Fe-C); Cu-Zn (brass) does not show any tendency to segregation, and this holds for Hg-Pb as well, even with rapid cooling. The inverted segregation means that in Cu-Sn, *e.g.*, the core of the ingot contained more Cu than the edge; that the direct contact of the alloy with the iron of the mould made no difference was shown by lining the mould with kaolin. The decisive factors for the local distribution of the constituents seem to be the rate of crystallisation of the mixed crystals, which rate will differ along the different crystallographic axes, and the rate of diffusion. Normal block segregation takes place when there is no preferential rate of crystal growth in any direction; the crystals form in the chilled portion and push the liquid inward. In brass the rate of crystal growth is low, and the rate of diffusion high. H. B.

1762. *Use of Spectrographic Analysis in Metallurgy. Dissociation Spectra of Special Steels.* **A. de Gramont.** (Rev. de Mét. 19. pp. 90–100, Feb., 1922.)—In a previous paper [Abs. 438 (1921)] the author has given a list of the ultimate lines in the spectra of a large number of elements. It has been found that for certain elements, particularly those employed in special steels, spectroscopic data not only give a very sensitive means of detecting the presence of these elements, but also give a close approximation to the percentage proportion. With a series of special steels of known composition, serving as types, a scale may be easily constructed, based on the successive disappearance of the spectral lines. From this scale approximate quantitative analyses can be very rapidly obtained by simple inspection of spectrograms. In a series of researches not yet completed, the method has been shown to give good results for the elements Al, B, Cr, Co, Cu, Mn, Mo, Ni, Si, Ti, W, and Va. The method is described in detail, and a number of examples of the identification of Cr, Ni, Co, Mo, W, Va, and Ti in varying proportions in different steels are given. A. W.

1763. *Contribution to the Study of Quenching.* **A. Poucholle.** (Comptes Rendus, 174. pp. 611–613, Feb. 27, 1922.)—Studies of the changes in length of a eutectoid steel wire 1 mm. in diam. and 1 m. long, during cooling in air. Such cooling, which is rapid enough to be regarded as quenching, causes the *Ar*1 point to take place at low temperatures. Magnetism does not reappear, during quenching, till *Ar*2 is reached, that is, till the temperature has fallen to 200° C. It is in the range between 650° and 200° C. that mechanical stress is set up. The amplitude of *Ar*1 is reduced by raising the temperature or by increasing the duration of heating. J. L. H.

1764. *Use of Thermo-E.M.F. in the Identification of certain Steels.* **Galibourg.** (Comptes Rendus, 174. pp. 547–550, Feb. 20, 1922.)—The Brinell test, on annealed metal, permits of the identification of ordinary steels, but fails in the case of special steels. The determination of the thermo-e.m.f. (against pure iron) enables ordinary and special steels to be arranged in an order different from that given by the Brinell test, and hence furnishes a second equation for determining the composition of a steel when it is not possible to submit it to chemical analysis. A convenient arrangement for carrying out the experiments is described. J. L. H.

1765. *Recrystallisation of Copper-Zinc Alpha Solid Solution.* **M. Cook.** (Faraday Soc., Trans. 17. pp. 522–524, Feb., 1922.)—Gives the results of experiments on the recrystallisation and homogenisation of unworked alpha brass containing 70 % Cu. The brass used was cast into ½-in. open iron moulds, and the ingots thus obtained were annealed for different periods of time at different temperatures, and then examined microscopically. When annealed for periods up to 7 hours, at 400 to 500° C., no perceptible change is noted in the original structure, the cored structure [Abs. 374 (1919)] being very stable. When the annealing temperature reached 600° the change of structure became very marked with different periods of annealing, and specimens annealed at 650 for more than one hour became completely homogenised. C. O. B.

1766. *Grain-Growth and Recrystallisation in Metals.* **Z. Jeffries** and **R. S. Archer.** (Chem. and Met. Eng. 26. pp. 343–345, Feb. 22; 402–410, March 1, and pp. 449–457, March 8, 1922.)—A series of articles dealing with the sizes and shapes of grains produced on the solidification of metals, with grain-growth in the solid state, and with recrystallisation. The authors commence by referring to recrystallisation, which they define as "the structural change produced in cold-worked metal on changing from the strain-hardened state to the annealed state" and they give a table of recrystallisation temperatures, which temperatures they define as the lowest that, after severe cold work, will produce new grains visible under a high-power microscope. If a strain-hardened metal is heated to a temperature just below that of recrystallisation, no visible grain-growth takes place. At higher temperatures grain-growth takes place, still higher temperatures and extended exposures producing larger grains. Cold-worked materials generally can be recognised by the distorted grains, but a distorted grain shape is not necessarily a proof of strain. Pure metals, caused to solidify rapidly, generally show a smaller grain size than when they solidify slowly, but the converse is often true of solid-solution alloys. The effect of annealing temperature, and annealing time, on grain size is next discussed, and typical curves are given. The conclusions drawn are, that (1) under certain conditions of temperature a grain size is established in a very short time, which is stable so long as the metal is not subjected to a higher temperature, and (2) there is, in some metals, an intermediate temperature range, in which grain-growth continues for long periods, and very large grains may be developed. Certain combinations of non-uniformity of structure or of temperature (strain or temperature gradients) give rise to the production of abnormally large grains (germination). The temperature range within which these grains are formed is called the germinative temperature. The germinative temperature increases as the strain decreases, and when the annealing temperature is well above the germinative temperature the grain size produced is smaller than it is with the same degree of strain but an anneal at the germinative temperature. Germination can be produced by incorporating the proper amount of obstruction matter and heating to a certain temperature. The higher the germinative temperature the larger will be the grains and the quicker they will form, while the more rapid the heating through the germinative temperature the finer will be the grain size.

Causes of Grain-Growth.—Grain-growth results from the tendency of matter to assume the form of greatest physical stability. The most stable form in metals is that of the least surface energy, which will be a single crystal grain, probably either idiomorphic or spherical, of smooth surface, and free from any distortion of its space-lattice. In general, in an aggregate of grains of various sizes, the larger grains tend to grow at the expense of the smaller; this growth may be regarded as a competitive process, at a boundary between two adjacent grains, for the surface atoms or the atoms in the amorphous cement. The causes favouring grain-growth are small grain-size and great grain-size contrast. Recrystallisation may be regarded as the growth to visible size of some of the fragments in the strained metal. The condition for germination is the existence of marked grain-size contrast in a metal at a temperature which permits absorption of the smaller grains by the larger, but not growth among the smaller grains. An obstructing material, present in a given quantity and mode of distribution, exerts its max. obstructing effect on grain-growth with respect to grains of a certain size. The paper is illustrated by many examples, mostly from the behaviour of tungsten. J. L. H.

1767. *Valency Scales of Iron, Cobalt, Nickel, Copper, Tin, Tungsten from their Water-Vapour Equilibria. Dissociation Pressures of the Oxides.* **L. Wöhler** and **O. Balz.** (Zeits. Elektrochem. **27.** pp. 406–419, Sept., 1921.)—The authors hold that, in forming chlorides and oxides, the polyvalent metals pass successively through the various valency stages, *e.g.*, $IrCl$, $IrCl_2$, $IrCl_3$, $IrCl_4$. The free energy of formation decreases in the order stated; at constant temperature the pressures of the chlorine or oxygen diminish, at which the respective compounds remain stable. Hence not all the possible compounds need be known, as some will be unstable, and the first and second compound may be formed simultaneously, or the second at once without the first. Since the dissociation pressures of the oxides are very small, the authors study the equilibria between water-vapour and the solid phases. Making use of the apparatus of Wöhler and Prager (*ibid.*, **23**. p. 299, 1917), the authors heat, *e.g.*, Fe_2O_3 in an electric furnace in the presence of a measured volume of hydrogen, and also oxidise iron by means of aqueous vapour. Against Schreiner and Grimnes [*ibid.*, **12**. p. 782, 1906] they maintain the necessity of artificial circulation; the peculiar bends in the curves of these workers and of Chaudron are not noticed then. From the equilibria Fe_2O_3/Fe_3O_4, Fe_3O_4/FeO, and FeO/Fe they conclude that the stability of the oxides decreases in the order Fe_2O_3, Fe_3O_4, FeO. At a red glow Fe passes into FeO, and not into a mixture of metal and Fe_3O_4. A mass effect suggesting the formation of solid solutions is not observed. In the case of cobalt the oxide Co_2O_3 is already decomposed at moderate temperature; heated in oxygen, at 300 or 400°, CoO turns into Co_3O_4, which is again decomposed below 600°; reduction of Co_3O_4 yields CoO, and then metal; there is no suboxide (Co_2O). The nickel oxide Ni_2O_3 is still less stable than the Co_2O_3; heated in oxygen it turns into the black velvety Ni_3O_4, which is not stable either; there is no suboxide. In the case of copper the two oxides Cu_2O and CuO are produced simultaneously; there is no other oxide. Nor are there more than the two tin oxides, SnO_2 and SnO. In the case of tungsten there exist the yellow oxide WO_3, the bluish-violet W_2O_5, and the brown WO_2, but no other oxides; again the formation of solid solution was not observed; all the tungsten oxides are slightly volatile above 800°.

The authors also attempt to determine the heats of formation of the iron oxides; the dissociation pressures indirectly deduced are of the order of 10^{-11} or 10^{-12} mm. of mercury. H. B.

1768. *Theory of Hardening.* **O. E. Harder.** (Chem. and Met. Eng. **25**. pp. 647–648, Oct. 5, 1921. Paper read before the Am. Soc. for Steel Treating.)—Many alloys, including carbon steels, alloy steels, duralumin, and certain Al-Mg alloys can be usefully hardened, and experiments with them yield many points in common. For example, well-made annealed pieces when cooled at a correct rate after an appropriate heating, possess an increased hardness and exhibit a structure consisting of an assemblage of polyhedral crystals all alike, i.e. a solid solution. These pieces can be further hardened, sometimes by mechanical work, sometimes by further cooling, sometimes by ageing at room temperatures, and always at a rapid rate by tempering. The last-mentioned increase in hardness may be accompanied by no change in microscopic appearance. These facts conform to the supposition that a substance which existed in the original piece is much more soluble at a high temperature than at lower temperatures. The changes which take place when carbon steel is heated and cooled are mentioned, and it is pointed out that quenching locks the solute and solvent in a metastable condition, and the tendency for the now insoluble solute to precipitate exists, although there is not the necessary internal mobility or plasticity to allow of the atomic rearrangements. It is suggested that max. hardness ensues after this condition of false stability has changed into one of actual instability and complete precipitation of the insoluble constituent has occurred in the form of the finest possible particles which can exist as separate crystalline entities, but far too small for microscopic observation. As an example, quenched nickel steel is austenitic; it is in the metastable condition. Further cooling decreases the solubility of the carbide more and more until finally the tendency to precipitate overcomes the hindering forces, and actual precipitation of cementite occurs with evolution of heat, resulting in the appearance of martensite and an increase in hardness. These tiny particles will accumulate into larger ones if given an opportunity, and tempering allows this. Jeffries and Archer's critical dispersion is thought to be that point where the softening effect of crystalline growth becomes of greater magnitude than the hardening effect of continuing precipitation of tardy particles. Rosenhain's theory connected with the hardness of solid solutions is referred to, but it is pointed out that this does not cover heterogeneous systems after precipitation has commenced. It is suggested that the action of alloys in steel or other metals is principally one of retarding or catalysing, as the case may be, the processes of solution or precipitation. The conception that unusual hardness is associated with the presence of an intermetallic compound of variable solubility and of the effect of additional metals in catalysing the solution and precipitation processes, should be of great assistance in the search for new, useful alloys. C. O. B.

1769. *Mechanical Properties and Microstructure of Pure Rolled Zinc.* **D. H. Ingall.** (Inst. of Metals, J. 26. pp. 281–308; Disc., and Comm., 309–320, 1921. Engineering, 112. pp. 489–492, Sept. 30, 1921.—Abstract.) —A summary of previous work on the microstructure and mechanical properties of zinc is given, and new methods of polishing and etching are described. Absolute values for the mechanical properties are not obtainable, as the material is too variable, but it is shown that zinc is stronger across the direction of rolling than with it. Conversely, the ductility is less across the direction of rolling than with it, except when the material has been reduced by more than 95 % by the rolling. Annealing for 30 mins. at 200° C. renders the metal weak and brittle, due to coarse crystallisation. J. L. H.

1770. *Thermal Analysis of Binary and Ternary Bismuth-Lead-Tin Alloys.* **J. Würschmidt.** (Zeits. f. Physik, 5. 1. pp. 39–53, 1921.)—The author, together with Callisen and K. Gilbert (Dissertation, Erlangen), studies various Rose metals, about the melting-points of which there is a considerable discrepancy. An alloy of two metals which are completely miscible in the liquid state, but not in the solid state, has, according to E. Wiedemann, two melting-points: a fixed melting-point of the eutectic, and another point which may be nearer the melting-point of the component present in excess or the melting-point of the eutectic. In the case of Pb-Sn there are two expansion maxima, corresponding to the two melting-points; in Pb_3Sn, the upper maximum is missing, and this alloy is hence the eutectic. Matters are different for Bi-Sn, since Bi contracts on melting; the eutectic has a minimum expansion, and the second melting-point corresponds to a minimum coefficient when Bi is in excess, and to a maximum when Sn is in excess; the alloy Bi_2Sn_3 has only the first minimum, and is hence the eutectic. The Pb-Bi eutectic is Pb_7Bi_6. The author takes heating and cooling curves of a large number of alloys, first of Bi-Sn, with the aid of thermo-couples, in order to determine the upper melting-point; from 40 to 100 gm. of metal are used, and the range to be studied is divided into several portions, in each of which the thermo-current is compensated by an accumulator current with the aid of a simple arrangement. The eutectic melts at 140°, and contains 46 % (atomic) of Bi. The ternary alloys similarly studied indicate the eutectic Bi_2SnPb melting at 96°. The results are summarised in 20 tables and curves.

H. B.

1771. *Recrystallisation of Metals. Cold-Worked Zinc.* **G. Masing.** (Zeits. f. Metallkunde, 13. pp. 425–428, Sept., 1921.)—The zinc was hammered, rolled down to 0·1 mm. thickness, etched with diluted chromic acid, and then heated for about 4 hours up to 350° C., different specimens being withdrawn for examination at different temperatures. Up to about 190° the grain was little influenced by the heating; above this big secondary crystals appeared, which were soon dissolved again on prolonged heating. These secondary crystals are the coarser, the slower the heating and the lower the initial temperature of their formation. Grains for the secondary crystallisation seemed to be formed between 150 and 170°; the recrystallisation need not be completed within the short period of Czochralski, a quarter of an hour.

H. B.

1772. *Microscopical Detection of Lead, Tin, Iron, in Brass.* **A. Drogseth, H. Engelmann,** and **W. Guertler.** (Zeits. f. Metallkunde, 13. pp. 238–243, May, 1921.)—The contamination of brass with lead, tin, iron, etc., having become very common during the war, owing to the dearth of pure raw materials, the authors show by photographs (magnification mostly 36), how these metals can be detected in brasses which may have undergone various treatments. The presence of Ni influences the crystals on the whole as if the Cu percentage were increased. Manganese acts like Ni, but tends to make the grain finer. Lead is best recognised by irregular dark spots, before and after etching. Tin influences the structure somewhat like an increase in the zinc percentage; etching with ferric chloride shows bluish grains, whilst iron turns black. This etching test is most convenient for the recognition of iron.

H. B.

1773. *Zirconium Metal, Compounds and their Uses.* **J. W. Marden** and **M. N. Rich.** (Bureau of Mines, Bull. No. 186. [152 pp.] 1921.)—The chief ores are zircon, $ZrSiO_4$, and baddeleyite, ZrO_2; zirkite is a trade name for the native oxide. The authors tried all known and new methods, especially also for the preparation of the metal. The ores are fused with caustic soda, soda ash, or nitre cake, or extracted with sulphuric acid; zircons are more difficult to resolve than zirkites. In the laboratory recrystallisation of the double fluoride K_2ZrF_6 gives a pure product; the less expensive oxychloride crystallisation will work when Na, Fe, Al are practically absent; the basic sulphate method promises best. To prepare amorphous zirconium the K_2ZrF_6 is fused with Na or Al, or electrolysed in fused state; a metal of 98 per cent. is obtained, a soft velvety black powder, melting about 1700°, density 4, slowly attacked by water and by various chemicals. The direct reduction of ZrO_2 by powdered Al does not give a button of metal; the amorphous metal contains some oxide. To attain a coherent, non-porous metal arc fusion of the fluorine double compound with Al in an Arsem vacuum furnace is satisfactory; when a hydrogen atmosphere at reduced pressure is provided, the little Fe and Si in aluminium cause trouble. Arcs between rods made out of the compressed amorphous metal in hydrogen also yield compact metal. This metal absorbs hydrogen, and spits like silver; it resists chemicals and atmospheric corrosion much better than the amorphous metal, is only dissolved by hydrofluoric acid, and very slowly by *aqua regia*; the metal has a white colour, hardness 4 or 5 on the Mohs scale, and is brittle. Anodes of zirconium are attacked by sulphuric acid. The metal does not alloy readily, though more so than the amorphous powder; alloys with steel were said to have been used in Germany during the war for armour plating and tool-steel; the authors found them all hard and brittle; the alloys can be obtained in the arc furnace from zirkite, powdered iron, and fluorspar. Zirconia crucibles were improved by mixing the oxide with phosphoric acid or sulphuric acid; but they also crumbled like zirconia crucibles at the highest temperatures. A very complete literature list is given. H. B.

1774. *Influence of Lead on the Strength of Bronzes.* **J. Czochralski.** (Zeits. f. Metallkunde, 13. pp. 171–176, April, 1921.)—The alloy tested contained about 86 per cent. of Cu, 9 Sn, and 5 Zn, and up to 6 per cent. of Pb, mostly at the expense of the copper. The tests of tensile strength and elongation, Brinell hardness, torsion, and impact strength show that the addition of Pb, up to 6 %, is not deleterious but even advantageous as to casting and machining, provided the material and specimens be well prepared. The specimens cast in coquilles were a little stronger than those cast in sand. The metallographic examination shows that the bronzes would dissolve up to 8 per cent. of lead; marked segregation of lead only took place when 6 % was exceeded; in such cases failure was connected with lead segregation. When the specimens are etched with ammonium persulphate, the lead assumes a pale bluish colour. H. B.

1775. *Influence of Antimony on Bronzes.* **J. Czochralski.** (Zeits. f. Metallkunde, 13. pp. 276–281, June, 1921.)—Similar tests [see preceding Abs.] made with bronzes containing up to 3 % of Sb in addition to 0, 2, or 5 % of Pb indicate that Sb in percentages up to 0·3 is not detrimental to bronzes, even if 5 % lead be present at the same time. Metallographically antimony has the effect of a further addition of tin. In the case of lead some of the technical properties of the alloys are favourably influenced by the addition of lead (6 per cent. maximum): the alloys are more easily matured and cast, and the alloy need not be heated to high temperatures to pour well. In the case of antimony (0·3 % maximum) the properties are not unfavourably affected; the castings fill the mould well, and threads can be cut. H. B.

1776. *Influence of Arsenic on Bronzes.* **J. Czochralski.** (Zeits. f. Metallkunde, 13. pp. 380–383, Aug., 1921.)—Experiments made as with lead [see preceding Abstract] show that the addition of As to bronzes has on the whole no deleterious influence on the mechanical properties of the bronzes so long as the arsenic percentage does not exceed 0·3, even in the presence of 5 per cent. of lead. The tensile strength is slightly increased, the elongation diminished as up to 0·3 % As is added, to decrease afterwards; further addition of up to 2 % As makes no difference. The torsional strength falls off rapidly above 0·3 % As, but not in presence of lead. The impact strength is decidedly lowered by any addition of arsenic; in the presence of lead there is first a slight rise. The hardness increases. Bronzes containing arsenic can be cast and machined as well as in the absence of arsenic, and give clean threads. The results agree on the whole with Heyn's previous experiments and with those of Rolfe on gun-metal [Abs. 1171 (1921)]. H. B.

1777. *Spontaneous Transformation of Alloys: Rose Metal.* **F. Hauser.** (Zeits. f. Physik, 5. 4. pp. 220–226, 1921.)—The experiments were made with a Rose metal $Pb_2Bi_4Sn_4$. The cooling curve shows arrests at 112° and 97°, and near 46° the rate of cooling is retarded. The author pours this alloy through a plaster funnel on a clean glass surface; old photographic plates are used, because the film at the back keeps the plate whole when the glass cracks. The metal cake is taken off the plate, and the plane surface examined in diffused daylight under a Leitz microscope. The surface first forms a bright mirror; then wartlike spots develop below 50°, and in less than an hour the whole assumes a crystalline structure. To ascertain the temperature of the transformation, the cake was reheated in a small electric furnace up to 72° for 3 hours and very slowly cooled; the temperature of transformation seems to be 41°. Sudden quenching hastens the transformation, but some bright-mirror spots may remain, which change slowly. Watched with the naked eye, the transformation is manifested by light-flashes. Tin amalgam behaves similarly, and the transformation is there more distinctly accompanied by sound (Tin *cry*, C. Drewitz, Dissertation, Rostock, 1902). H. B.

1778. *Silicothermy and Thermisilid.* **R. Walter.** (Zeits. f. Metallkunde, 13. pp. 225–230; Disc., 230–233, May, 1921. Paper read before the Deut. Gesell. f. Metallkunde.)—When silicon is heated with metals, notably with iron, a strong reaction sets in above 1200°, and the temperature may rise to 1800°. This spontaneous heat generation is overlooked when silicon is gradually added to the fused metal, and is much diminished by the presence of carbon; it is hardly noticeable with cast iron. In preparing thermisilid, an acid-resisting silicon-iron, the author relies on this reaction; according to the proportions the silicides FeSi and Fe_2Si are formed, which dissolve in the iron; some silicon carbide is also formed. Definite information about the manufacture of thermisilid (by F. Krupp, of Essen, and the Maschinenfabrik Esslingen) was not given. It would appear that the materials are either powdered, or that the silicon or high-grade ferro-silicon is first separately fused. The microphotographs reproduced are to show that the structure of the alloy should be grainy, not dendritic, and the alloy should contain Fe_2Si, not FeSi; the latter decomposes. The boilers (2 m. diameter), retorts, valves, centrifugal pumps, etc., of thermisilid are described as acid-resisting, and nearly as strong as cast iron; they are corroded by chlorine and sea-water; the shrinkage is small. In the *discussion*, **Arndt** inquired whether the reaction set in when the vapour tension of the Si was sufficiently strong to break through the surface film of oxide, and whether electric furnaces were used; the author replied that he had not observed any surface films, and that electric furnaces had so far not answered. **Guertler** criticised the term silicothermy, since the silicon was not to reduce any metallic oxide in these reactions. **J. Bronn** gave some notes about the melting in electric furnaces of the ferro-manganese and ferro-silicon to be added to steel. H. B.

1779. *Influence of Temperature on the Rate of Interpenetration of Solids.* **H. Weiss** and **P. Henry.** (Comptes Rendus, 174. pp. 292–294, Jan. 30, 1922.)—In order to ascertain the influence exerted by the temperature on the rate at which metals interpenetrate, use is made of an alloy containing 14 parts of Ag per 100 parts of Sb [Abs. 409 (1922)], which consists of a white solid solution rich in silver containing violet-red dendritic masses of the compound Ag_3Sb. Portions of a uniform sample of this alloy were sealed in glass tubes evacuated to a degree not measurable by a MacLeod gauge, some of the tubes being then heated at 500° and some at 545°. The values found for the ratio between the times taken for the samples to assume similar appearances at the two temperatures vary from 1 : 2·5 to 1 : 2·1, and may thus be regarded as constant. The results obtained may be expressed by the equation : $v = 1/\theta = Ka^T$, where v is the velocity of interpenetration, θ the time in hours, and T the absolute temperature, and K has the value $4 \cdot 17 \times 10^{-12}$ and a 1·0324. It remains to be determined if a temperature exists at which the rate of homogenisation is zero. T. H. P.

1780. *Constitution and Age-Hardening of Si-Mg-Al Alloys.* **D. Hanson** and **M. L. V. Gayler.** (Inst. of Metals, J. 26. pp. 321–355 ; Disc., 356–359, 1921. Engineering, 112. pp. 519–522, Oct. 7, 1921.—Abstract.)—The constitution of alloys containing up to 12 % Si and 35 % Mg has been investigated, and is illustrated by means of a wire model. Diagrams illustrating various sections through the model are shown. Some of these are cut parallel to the Al-Mg side of the prism representing the constitution, while others are parallel to the base. In addition to this a number of drawings illustrating definite reaction planes in the model are shown. Two views, showing the separation of the compound Mg_2Si, which occurs even in alloys containing as much as 98 % of Al, are given, and many photomicrographs are reproduced.

(2) *Age-hardening.*—It appears that the amount of age-hardening is roughly proportional to the amount of magnesium silicide in solution at the moment of quenching, the ageing being due to the fact that, on quenching, Mg and Si are retained, probably in solution, in an unstable state from which they tend to revert to a more stable form. It would appear that the gradual hardening is due to the gradual changes which take place in the alloy as a result of the tendency to the formation of separate crystals of Al and Mg_2Si, existing side by side in the alloy. J. L. H.

1781. *Action of Selenium upon Gold.* **H. Pélabon.** (Comptes Rendus, 174. pp. 391–392, Feb. 6, 1922.)—The author has pointed out the variations which the resistivity of Se undergoes when the temperature is increased regularly up to its boiling-point [see Abs. 1818 (1921)] and 997 (1922)]. These variations can be explained by the existence of two modifications, α and β, when gold electrodes which do not vary in weight are used. When a sheet of gold, first of all polished and then kept several hours in contact with Se at a temperature near its boiling-point, is examined microscopically, a modification of the surface of the plate is clearly visible. Without doubt the surface of the gold is attacked by the Se. It is probable that the Se deposited on the surface of the metal hinders further attack. When a large sheet of gold is heated (to 610° about) for several days in selenium liquid, and subsequently heated in the flame of blowpipe so as to remove any free Se, it is found that there is a very slight increase in weight. It also seems that gold melts more easily after such treatment. As generally gold electrodes do not vary in weight, the fixation of Se upon the plate must be compensated by a loss of metal. Evidence is given which appears to show that the gold in very minute quantity is dissolved in the Se, or else the two elements form an unstable combination. So that, contrary to what has been accepted up to the present, it is now suggested that gold is attacked by Se: there is a partial exchange between the two elements. The Se which has been called β is not, then, a pure body. The feeble resistivity is to be explained by the presence of gold dust which it holds in suspension, and by the needles of Se which traverse it. It still remains to be explained why this impure Se may be made of exceedingly high resistivity by a series of oscillations of temperature.

A. E. G.

1782. *Preparation of Boron Carbide from Boric Acid and Carbon in the Electric Furnace.* **J. M. Logan.** (Roy. Soc. Canada, Trans. 15. Sect. 3. p. 58, 1921.)—Boric acid was mixed in different proportions with graphite, charcoal, or electrode carbon, and heated to different temperatures from 800° to 1800° C. in closed carbon tubes or plumbago crucibles by means of a granular carbon resistance furnace; some runs were made in the Moissan arc furnace. The best results were obtained by 2 hours' heating at over 1800° C. in crucibles turned from 4-in. carbon electrodes. Crystals of the same form were obtained whether carbon or boric acid was present to an excess of 25 %. AUTHOR.

1783. *Durability of Glass.* (Engineering, 113. p. 138, Feb. 3, 1922. Abstracts of 3 Papers read before the Soc. of Glass Technology.)—*Extension of Zulkowski's Theory on the Relation between Composition and Durability.* **W. L. Baillie.**—Zulkowski assumes that simple silicates are first formed which subsequently combine to the double silicates characteristic of serviceable glassware; the second, slower reaction, requires that a sufficiently high temperature be maintained for an adequate period. If one type of base, alkali or lime, were molecularly in excess, simple unstable silicates would remain in the glass and would persist irrespective of fusing. The author modifies Zulkowski's formulæ as to the desirable proportions of bases RO and acidic oxides R_2O_3 and SiO_2, and gives a formula for the "reactivity coefficients." The value of this coefficient should not exceed 5. Zulkowski's theory did not explain the durability of glasses containing considerable proportions of Al_2O_3 and B_2O_3.

Methods of Determining the Durability. **W. E. S. Turner.**—It is better to determine the alkali liberated than the loss in weight. The results depend upon the shape and size of the vessel, beaker, or flask, and on the area in contact with the liquid. Four methods are indicated: static method with flasks and beakers; slabs and discs immersed in the liquid; autoclave method; glass ground to mesh 20 or 30, rather than 160 (Peddle).

Effect of Magnesia on the Durability of Glass. **[Miss] C. M. M. Muirhead** and **W. E. S. Turner.**—Comparative tests of the action of certain reagents in magnesia glass and lime glass. Boiling with water for one hour of the ground glass liberates more sodium oxide from lime than from magnesia glass. Discs of magnesia glass resist boiling hydrochloric acid better than lime glasses. The effect of increasing the proportion of magnesia is less great than in the case of lime, and magnesia glasses lose more weight in boiling caustic soda or sodium carbonate. On the whole the hard glasses do not differ much in corrodibility. H. B.

1784. *Change of Properties of Substances on Drying.* **H. B. Baker.** (Chem. Soc. J. 121. pp. 568–574, April, 1922.)—The boiling-points of a number of liquids which have been left to dry for eight or nine years in contact with phosphoric oxide show the following very considerable rises: bromine, from 63° to 118°; mercury, from 358° to 420–425°; hexane, from 68·4° to 82°; benzene, from 80° to 106°; carbon disulphide, from 49·5° to 80°; carbon tetrachloride, from 78° to above 112°; ether, from 35° to 83°; methyl alcohol, from 66° to above 120°; ethyl alcohol, from 78·5° to 138°; propyl alcohol, from 95° to 134°. The hypothesis that this phenomenon has its cause in increased molecular complexity receives support from preliminary determinations of the surface tensions of the dried liquids. The melting-points of sulphur and iodine show rises of 5·5 deg. and 2 deg. respectively, after nine years' drying. The densities of various liquids exhibit no change after these were dried for a year in contact with phosphoric oxide. T. H. P.

1785. *Optical Method for the Determination of the Reciprocal Solubility of Sparingly Miscible Liquids.* **C. Chéneveau.** (Comptes Rendus, 174. pp. 815–817, March 20, 1922.)—In this method, which gives results at least as accurate as those yielded by the gravimetric method, use is made of autocollimation, this being rendered differential. A hollow prism with sides of parallel-faced glass sheets is divided into two compartments, A and B, the inclination between the two working faces being in each case the angle of the prism, r. Compartment A is filled with the liquid regarded as the solvent and B with the mixture of this with the other liquid. The reflecting rear face of the prism may, if necessary, be silvered. If i' and i are the angles of incidence for A and B respectively when autocollimation holds with the D line, and n and N are the indices of refraction for the liquids in A and B respectively, it is shown that $N = \sin i/\sin r$, $n = \sin i'/\sin r$, and $N - n = \sin \alpha \cos (1 - \frac{1}{2}\alpha)/\sin r$. Further, an equation is given by means of which the value of x, the number of gm. of the liquid solute that are dissolved in 100 gm. of the solvent can be determined. T. H. P.

1786. *Application of Ideal Solution Equations to Dilute Aqueous Solutions.* **J. Kendall.** (Am. Chem. Soc., J. 43. pp. 1391–1396, July, 1921.)—The essential incompatibility of the fundamental ideal-solution equation, as applied at present to dilute aqueous solutions, with the dilute-solution vapour-pressure depression equation and with the results of experiment has been pointed out. It is shown that the discrepancy disappears when due notice is taken of the fact that the vapour pressure of water at ordinary temperatures must be ascribed practically entirely to its monomolecular fraction, the shift in the equilibrium $(H_2O)q = q(H_2O)$

on addition of solute counterbalancing the effect of the association upon the molar fraction. **Author.**

1787. *The Law of Distribution of Particles in Colloidal Solution.* **E. F. Burton** and **[Miss] E. Bishop.** (Roy. Soc., Proc. 100. pp. 414–419, Jan. 2, 1922.)—The work of Perrin and his collaborators on the experimental and theoretical application of the results of the kinetic theory to colloidal solutions is probably the most complete exposition extant of this phase of activity. Perrin shows that a law of distribution of the particles in a colloidal suspension should be expected analogous to that regulating the distribution of the molecules of air in the atmosphere. By balancing the osmotic pressure of the particles in solution against the effect of gravity, he deduces an equation for the numbers of particles per cm.^{3} at depths h and h_0 from the top of the solution. He tests the reliability of this equation by observations on gamboge particles of $2 \cdot 12 \times 10^{-5}$ cm. diam. and $5 \cdot 2 \times 10^{-5}$ cm. diam. As pointed out by Perrin, the concentration at a distance $9 \cdot 6 \times 10^{-3}$ cm. from the bottom of the dish would only be 1/60,000 of that at the bottom, and he adds, " hence, when permanent equilibrium has been reached, grains will hardly ever be found in the higher layers of such preparations."

The author finds by calculation that the increase in concentration down a tube of a few cm. depth would be an enormous multiple of the concentration at the top, and he points out that in Perrin's experiments on gamboge particles, these were very large compared with the particles of ordinary colloidal solutions. He finds that successful observations with emulsions of colloidal metals cannot be made through heights of several cm., or even mm.; heights of less than one-tenth of a mm. only are suitable. Whether so intended by Perrin or not, his formula has been taken to hold for all colloidal solutions and for all depths, and the present author shows the impossibility of such an extension of Perrin's work. Experimental work is described on colloidal solutions standing for some time in a long vertical tube, from which layers could be drawn off at different heights. It is found that even if Perrin's law holds over a small depth, a limiting concentration is soon reached, so that no difference in density is shown for considerable depths. The concentration thus tends to become uniform, and is regulated by some definite properties of the particles. There appears to be a limiting concentration of metal which a given liquid will retain in the colloidal state. To test this conclusion, 800 cm.^{3} of silver hydrosol were prepared and gradually evaporated. At the beginning and at each successive stage at which the volume of the liquid evaporated reached a half value, the amount of metal per cm.^{3}, the mobility of the particles, and their sizes were determined. From the data recorded, the size of the particles and their mobility is apparently not affected by the concentration of the solution, but there appears to be a limit to the quantity of colloidal silver possible in water, at about 13 mgm. per 100 cm.^{3}. The only conclusion to be drawn, after taking sources of error into account, is that, fundamentally, suspensions of fine particles always reach a uniform distribution throughout the body of the liquid, and the variation expressed in Perrin's distribution law must be confined to a very small distance at the surface. H. H. Ho.

1788. *Probability of Spontaneous Crystallisation of Supercooled Liquids.* **C. N. Hinshelwood** and **H. Hartley.** (Phil. Mag. 43. pp. 78–94, Jan., 1922.)—The object of the experiments described in this paper was to determine the mode of variation with temperature of the probability of crystallisation, and to throw light on the nature of the causes leading to the formation of a crystal nucleus in a supercooled liquid. Tammann has measured the variation of linear velocity of crystallisation with temperature, and also the number of nuclei formed in a mass frozen suddenly at different temperatures, but not the probability of crystallisation—i.e. the probability of the formation of a single nucleus from an initially homogeneous liquid. A statistical method was adopted for a number of substances including salol, phenol, *p*-toluidine, diphenylamine, and *o*-nitro-phenol. The procedure was to fill about 100 tubes, seal and tie them to a board; then to melt the contents by immersion in a bath of water at a known temperature above the melting-point, sufficient time being allowed to ensure that all crystalline nuclei had dissolved. The tubes were then transferred to a thermostat, and the number of crystallisations observed from time to time. When one experiment was completed, those tubes in which crystallisation had not taken place were induced to crystallise so far as possible by immersion in cold water. The whole set was then melted and a fresh experiment begun. The study of the phenomenon is complicated from the outset by the fact that the formation of a nucleus is a catalytic process, and that crystallisation is provoked by the colloidal organic dust particles from the air. The activity of these particles diminishes in general as the result of heating or ageing, while their effectiveness depends upon their radius. If this is equal to the radius of a small particle of the solid which should thermodynamically be in equilibrium with the supercooled liquid, then crystallisation occurs at once. If the radius is less than this, the supercooled liquid has an average life depending on the discrepancy between the equilibrium radius and the radius of the particles present. The magnitudes of these quantities are discussed at length. Tables of experimental data and curves for *p*-toluidine are included. H. H. Ho.

1789. *Electro-Chemical Properties of Metallically-Conducting Compounds.* **G. Tammann.** (Zeits. Elektrochem. 28. pp. 36–40, Jan. 1, 1922. Paper read before the Deut. Bunsen Gesell., Jena, Sept., 1921.)—In binary alloys giving mixed crystals, the chemical properties exhibited, and the p.d. given by the substance in contact with an electrolyte, are those of one or other of the separate components according to the proportion present. As the composition is varied a sharp transition point occurs at a certain ratio, when the properties of the alloy change from those of one constituent to the other. The compound Zn_3Sb_2 is, for instance, only 0·04 volt more noble than Zn, while the compound ZnSb has a value similar to Sb. For substances crystallising in the regular system, this transition point occurs at a molecular ratio which is a whole multiple of 1/8. The abrupt transition does not, however, take place at temperatures which are sufficiently high to allow of inter-diffusion of the atoms of the crystals, in which case the baser metal may collect at the surface and confer its properties on the crystal. These properties of mixed crystals at low temperatures are thus similar to binary crystalline compounds and indicate that the components occupy a definite position in the space-lattice structure, the main difference in the two types of structures being, in the case of mixed crystals, the ability of the components to separate by diffusion. In the case of a metallically-conducting compound of metal and metalloid, such as a sulphide or silicide, when in contact with an electrolyte an interchange can take place between the kation of the compound and a more noble kation in the electrolyte. During this change the potential gradually changes from the value for one kation to that of the other. This property would indicate that the crystal lattice is maintained by the metalloid atoms while the kations are exchangeable, and support is given to the theory that the atoms of electrolytically-conducting binary salts are ionised.

In the case of binary alloys or mixtures not forming mixed crystals, as, for instance, with amalgams, the potential approaches the value of that of the base metal, even when only very small amounts of the latter are present. This effect is similar to the phenomenon occurring with mixed crystals at temperatures which permit of the diffusion of the base metal from the space-lattice to the surface. J. N. P.

1790. *Structure of Mixed Crystals in their Solid Phases.* **L. Vegard.** (Zeits. f. Physik, 5. 5 and 6. pp. 393–395, 1921.)—Comparative X-ray spectra have been obtained for various mechanical mixtures of KCl and KBr crystals. The mixtures in all cases were made by mechanical pulverisation to a fine powder. The proportions of KCl and KBr were varied by taking: (1) equal quantities of KCl and KBr; (2) equal molecular proportions. In these cases the crystals were pulverised independently, and subsequently mixed for X-ray examination. It is shown that the mixing of crystals in the above manner results in a sharp-lined spectrum corresponding to the component crystals. If, however, the crystals are pulverised together in the above proportions, the lines of the X-ray spectra become more diffuse. The author discusses the importance of this observation and its bearing on the consideration of contact-phenomena of solid phases. A. B. W.

1791. *Hygroscopicity of Clay and Quantity of Water Adsorbed per Surface-Unit.* **S. Odén.** (Faraday Soc., Trans. 17. pp. 244–248, Feb., 1922.)—Measurements have been made of the proportions of hygroscopic or adsorbed water held by soils, mostly clays of various types, in atmospheres containing different amounts of water-vapour. The soil was allowed to lie in a large desiccator containing a water-sulphuric acid mixture of known vapour pressure until equilibrium was attained between the adsorbed water and the vapour pressure of the atmosphere, as shown by the constancy of weight of the clay. The acid was then replaced by more concentrated acid, and so on. For each clay a characteristic curve is obtainable, having as abscissæ the percentage of water calculated on the dry clay, and as ordinates the corresponding pressures of water-vapour. It is found that, the coarser the clay, the less the proportion of water held, and the closer the curves approach the axis of ordinates, whilst stiff, highly plastic clays give curves lying nearer to the axis of abscissæ. For nearly all clays the curves are concave to the axis of abscissæ, but that for Egyptian Nile clay from Korashin is almost rectilinear from 0 to 15 % of water, and afterwards makes a sharp bend.

Doubt has been expressed concerning Rodewald's theory that the surfaces of soil particles in equilibrium with the atmosphere over 10 % sulphuric acid solution are covered with a layer of water one molecule in thickness. Calculation on this basis of the average size of the particles from the surface area leads to impossible values, and shows such a theory to be untenable. Further, it is shown by means of the author's method of studying the rate of sedimentation in a clay slime and its variations during the sedimentation, which indicates the order of magnitude of the total surface area of the particles, that calculation from hygroscopicity to surface development is fallacious. T. H. P.

1792. *Diffusion of Solutions.* **T. H. Littlewood.** (Phys. Soc., Proc. 34. pp. 71–76, with Disc., April, 1922.)—An *optical method* is described for finding the *concentration* at various depths in a diffusing solution. The concentration can be determined at different depths, with an *accuracy* of about 0·05 gm. per litre.

The second part of the paper details the *method of calculating the coefficient of diffusion* from a series of measures at different times. AUTHOR.

1793. *The Principle of Induced Alternate Polarities.* **A. Lapworth.** (Chem. Soc., J. 121. pp. 416–427, March, 1922.)

1794. *Explanation of the Property of Induced Polarity of Atoms.* **W. O. Kermack** and **R. Robinson.** (Chem. Soc., J. 121. pp. 427–440, March, 1922.)—An attempt is made to show that the Thomson and Lewis-Langmuir theory of valency and electron configuration furnishes a satisfactory physical basis for certain modern hypotheses of organic chemistry. L. H. W.

1795. *Solubility of Crystal Faces; Equilibrium between Various Crystal Faces and Solution; Cubic and Octahedral Sodium Chloride.* **E. G. Haas** and **J. W. Russell.** (Roy. Soc. Canada, Trans. 15. Sect. 3. pp. 54–55, 1921.)

1796. *On a Possible Physical Interpretation of Lewis and Adams' Relationship between h, c, and e.* **G. A. Newgass.** (Phil. Mag. 43. pp. 698–700, April, 1922.)

1797. *A Continuous-reading Electro-Titration Apparatus.* **K. H. Goode.** (Am. Chem. Soc., J. 44. pp. 26–29, Jan., 1922.)—The simplest possible apparatus for electrometric titration, from a theoretical standpoint, would be a sensitive voltmeter connected between a calomel electrode and a hydrogen electrode. In practice, however, an ordinary voltmeter cannot be used, because the instrument would consume current enough from the cell to discharge the hydrogen electrode, and render it inoperative. For this reason all types of apparatus hitherto in use have depended upon balancing the unknown e.m.f. of the cell being used against a variable known e.m.f. produced by a potentiometer system, the balance being determined by a "null-point" galvanometer. With this type of apparatus a balance of potentials must be made before each reading of the voltage, and there is a considerable uncertainty in the readings when the potential of the cell is rapidly changing. The investigation described in this paper has shown that the 3-electrode valve ("audion") presents almost the ideal case of a "voltmeter" which draws no current from the source to be measured, and can therefore be employed as a continuous-reading instrument for determining the concentration of the hydrogen ion. A full description of the 3-electrode valve is given, with details of its working, and accompanied by diagrams and titration curves for HCl and H_3PO_4. The sensitivity of the apparatus described is of the order of 0·1 Sörensen unit, or 0·006 volt. Some difficulty was experienced in getting constant readings in regions of the curves where the Sörensen value changes abruptly, because the stirring necessary to produce a homogeneous solution resulted in a momentary decrease in the potential of the hydrogen electrode of about 0·02 volt. For this reason it was found necessary to stop stirring about 2 secs. before each reading was taken. With a constant stirring apparatus the author considers that it might be possible to allow for this effect. H. H. Ho.

1798. *Surface Tension of Electrified Electrolytes.* **G. Gouy.** (Comptes Rendus, 173. pp. 1317–1319, Dec. 19, 1921.)—The fact that the surface tension of an electrolyte is not modified by electrification [F. Michaud, Abs. 278 (1922)] is not a valid argument against the existence of ions, since the electric forces would repel as many ions of one sign as they would attract of the other. In any case the calculated effects are extremely small, of the order of 1 part in 2000, under the conditions used by Michaud, and would not be detected. It is also not unlikely that the surface film is already modified by the presence of the electrolyte, so that the ions are already concentrated in the surface, before electrification. T. M. L.

1799. *Abnormality of Strong Electrolytes and the Ionisation Theory of Ghosh.* **J. Kendall.** (Am. Chem. Soc., J. 44. pp. 717–738, April, 1922.)—A critical and rather destructive analysis is made of Ghosh's theory. I. H. W.

1800. *Molecular Refraction and Dissociation of some Fused Salts.* **G. Meyer.** (Zeits. Elektrochem. 28. pp. 21–23, Jan. 1, 1922. Paper read at Deut. Bunsen. Gesell., Jena, Sept., 1921. Heck, Dissertation, Freiburg, 1921.)—The compounds, nitrates, and hydroxides of K and Na, are fused in a silver crucible on the bottom of which is placed a mirror of pure silver or gold alloy. By means of a frame and some micrometer screws the crucible is suspended, not quite vertically, within an electric furnace, the mirror (and crucible) being so tilted that an incident ray is reflected back in its own direction through the fused salt. In KOH and NaOH only gold-copper mirrors could be used, for half an hour; hydrogen was passed through the furnace. The molecular refractions changed very little with the temperature (range 320 to 440°). The known atomic refractions for D light would yield the molecular refractions: hydroxyl oxygen 1·521, hydrogen 1·051, NO_3 8·95, Na 2·80, Na ionised 2·46; the mean molecular refraction found for $NaNO_3$ was 11·54, which would leave for Na 2·59. This value lies so between 2·80 and 2·46, that the fused $NaNO_3$ would appear to be ionised as to 61·7 %. The estimation could not be made for KNO_3, as the atomic refractions of ionised and un-ionised K are unknown. H. B.

1801. *Ionisation Produced by certain Quinine Salts.* **G. C. Schmidt.** (Zeits. f. Physik, 8. 3. pp. 160–164, 1922.)—Quinine nitrate, like the sulphate, ionises the air when heated. These quinine salts, when heated to fusion, are transformed into modifications which exhibit intense green fluorescence. T. H. P.

1802. *Quick-acting Hydrogen Electrode.* **P. J. Moloney.** (J. Phys. Chem. 25. pp. 758–761, Dec., 1921.)—In the hydrogen electrode described, the electrolyte is held by capillarity in a glass loop which surrounds a platinised Pt wire and is surrounded by an atmosphere of hydrogen. Equilibrium, as indicated by the attainment of a constant e.m.f., is reached very rapidly, usually in less than one minute, while the readings agree with those of a Clark electrode to within one millivolt. The electrode is capable of being rapidly washed and sterilised. The liquid to be measured may be contained in an open vessel, but with electrolytes depending for their acidity on the presence of dissolved CO_2, a closed vessel, such as a Michaelis' V-tube or a modification of Walpole's or Barendrecht's apparatus, must be employed, since otherwise the CO_2 would pass from the drop into the surrounding hydrogen, and the acidity as measured would be less than that of the original liquid. T. H. P.

1803. *E.M.F. of the Iodine-Silver Cell and the Heat of Formation of Silver Iodide.* **O. Gerth.** (Zeits. Elektrochem. 27. pp. 287–292, July 1, 1921.)—According to U. Fischer (1912) the heat of formation of AgI is about 15,000 cals. (mean of three methods); this value is slightly smaller than that of Koref and Braune (Nernst's heat theorem), C. Krahmer (Dissert., Berlin, 1919), and H. S. Taylor [Abs. 272 (1917)], but higher than that of Jones and Hartmann [Abs. 949 (1915)], 14,570 cals. To explain the discrepancy the author repeats the experiments of Fischer and of Jones and Hartmann. The discrepancy is traced to differences in the silver electrodes (those of Fischer were found superior) and in the temperature corrections mainly concerning the occurrence of I_3' in the KI solutions. H. B.

1804. *Electromotive Behaviour of Aluminium.* **A. Smits** and **G. J. de Gruyter.** (K Akad. Amsterdam, Proc. 23. 7. pp. 966–968, 1921.)—As a preliminary to the study of the electromotive behaviour of Al and its alloys with Hg, the melting-point diagram is first determined. The results are plotted and show an absence of compounds, and the melting-point line of Al consists of two branches with a transition point at about 585°. In the light of these results, the probable form of the e.m.f. diagram for the system Al-Hg at ordinary temperature is discussed. Experiments (not described) with Al salt + Hg salt solutions are stated to show that though in virtue of the concentration of the coexisting phases it would be expected that the potential of Al in an Al-salt solution would become less negative on the addition of a little Hg salt, the reverse takes place, even to a considerable degree. From this it is concluded that Hg dissolved in Al is a catalyst for the internal conversions in the Al. A. B. C. L.

1805. *Electromotive Relation of Aluminium; Remarks on a Publication of A. Smits.* **A. Günther-Schulze.** (Zeits. Elektrochem. 27. pp. 293–295, July 1, 1921.)—A critical article in which Smits's views [Abs. 186 (1921)] are challenged. L. H. W.

1806. *The CO/O₂ Element with Glass as Electrolyte.* **H. Kallmann.** (Zeits. Elektrochem. 28. pp. 81–85, Feb. 1, 1922.)—Continuation of the experiments of Haber and Moser on generator-gas cells [Abs. 622 (1906)], the gas being used at reduced pressure, mostly 70 mm., at which the hot CO may be more concentrated without being decomposed into CO_2 and C. Mixtures of CO and CO_2 of known proportions are introduced into a glass tube, the bottom of which is platinised both inside and outside, and brushes of platinum wire, with leads in quartz tubes, are pressed against these parts; the tube is heated in an electric furnace. In additional experiments the tube is charged with air or oxygen. The observed potentials agreed with the formula; technical applications are not suggested. H. B.

1807. *Contact Difference of Potential and Thermionic Emission.* **O. W. Richardson and F. S. Robertson.** (Phil. Mag. 43. pp. 557–559, March, 1922.)—Richardson has previously pointed out [Abs. 925 (1912)] that the following relation should subsist between the contact potential difference V between two surfaces at the absolute temperature T and their thermionic electron saturation currents i_1, i_2 per unit area at the same temperature; $V = kT \log i_2/i_1/e$; here k is Boltzmann's constant and e the electronic charge. Observations which confirm the validity of this equation approximately have been made by the authors experimenting with a thoriated tungsten filament. Details are given, and reference is made to a previous paper [see Abs. 1377 (1922)] on the effect of gases on the contact p.d. between metals for the general arrangements employed for evacuation and temperature control of the filament. After baking out the tube, exhausting with the mercury-vapour pump, etc., and heating the filament for some hours, it was found to have a fairly stable characteristic curve while, later on, the emission rose to an enormously higher value. The latter was lowered by reducing the filament temperature to a value comparable with that ruling before the change occurred, and the characteristic was again found to be stable. This displacement corresponds to a change of 0·71 volt in the p.d. between kathode and anode, and is in such a direction as to indicate that the filament had suddenly become relatively more electro-positive to that extent. There seems no reason to doubt that most of this change in the contact potential occurred at the heated filament, and assuming the whole change to be at the filament, the observations were found to furnish material for an approximate test of the above equation. H. H. Ho.

1808. *The Sodium-Oxygen Couple.* **E. Baur.** (Zeits. Elektrochem. 27. pp. 194–199, May 1, 1921.)—Fused caustic soda cannot entirely be dehydrated in an open vessel between 300° and 400°, as it absorbs water-vapour and it is not stable with respect to metallic sodium until the last traces of water have been removed; above 400° even the anhydrous caustic soda reacts with metallic sodium, forming oxide until equilibrium is set up. The author considers that the relative stability of sodium floating on anhydrous NaOH at 330° is due to the fact that a skin of Na_2O is formed on the Na, and that this skin dissolves with sufficient rapidity only above 400°. These features are important for the Na-O couples. In order to stabilise the sodium, F. Fischer places it within a small crucible (thimble) of magnesia standing in the fused caustic. There is more difficulty about the oxygen electrode. The author describes various arrangements tried: a Pt wire in a glass tube, through which hydrogen is passed, ending in Pt foil; silver tubes (for oxygen) enclosing a silver wire ending in a brush of fine silver wire; similar brushes and tubes of iron. Alloy of lead and sodium was also tried in the place of sodium. Potential measurements are given. The researches, in which A. Lund, D. Chervet, and S. Ott assisted, characterise the difficulties of the Na-O couple as not insurmountable. H. B.

1809. *Electrochemical Behaviour of Liquid Sodium Amalgams.* **T. W. Richards** and **J. B. Conant.** (Am. Chem. Soc., J. **44.** pp. 601–611, March, 1922.)—Improvements are described in the electrolytic preparation of pure liquid Na amalgams, in their subsequent manipulation, and in the apparatus employed for the measurement of the e.m.f. of Na amalgam concentration cells with aqueous electrolyte. Measurements have been made of the e.m.f. of a number of such concentration cells at 25° and of a few cells at 15° and 35°. The extents to which the results obtained deviate from the simple concentration law are found to be greater with Na amalgam than with any other mercurial solution hitherto studied in detail. The Helmholtz equation gives unusually high values for the heats of transference of sodium from one amalgam to another. T. H. P.

1810. *Solid Thallium Amalgams and the Electrode Potential of Pure Thallium.* **T. W. Richards** and **C. P. Smyth.** (Am. Chem. Soc., J. **44.** pp. 524–545, March, 1922.)—Pure compact thallium exhibits at 20° an electrode potential 2·1 millivolts higher than saturated Tl amalgam, and when immersed in a solution normal as regards thallous ions and connected with a normal calomel electrode, it gives a total potential of 0·6192 volt at 25°. The potential of pure Tl is not influenced by quenching the metal, which is so soft that it retains no appreciable stress. The only phase of the pure metal stable at the ordinary temperature is α-thallium. Finely-divided electrolytic Tl sponge yields a potential 0·6 millivolts higher than the compact fused form. With β-thallium, if it could exist at the ordinary temperature, the p.d. would probably be nearly three times as great. T. H. P.

1811. *Electromotive Behaviour of Magnesium.* **A. Smits** and **R. P. Beck.** (K. Akad. Amsterdam, Proc. 23. 7. pp. 975–976, 1921.)—Mg is stated to resemble Al closely in its electromotive behaviour, certain phenomena being weaker in the case of Mg. As a preliminary to the study of the electromotive behaviour of mixtures of Mg and Hg the melting-point diagram of the system Mg-Hg is investigated. A. B. C. L.

1812. *Potential of the Iodine Electrode, and the Activity of the Iodide Ion at 25° C.* **A. McKeown.** (Faraday Soc., Trans. 17. pp. 517–521, Feb., 1922.)

1813. *Mobility of Ions due to the Solvent* (*Water*). **G. v. Hevesy.** (Zeits. Elektrochem. 27. pp. 21–24, Jan. 1, 1921.)—The mobilities of the ions H· and OH′ (315 and 174 at 18°) far exceed those of other inorganic ions, ranging from 33 to 68. To account for this Danneel suggested in 1905, and others later, that the ions were in electrolysis those of water itself, and that they actually migrated in a kind of Grotthus's chain, colliding with water molecules which jerked off their own ions. The author doubts altogether that an ionic migration after Grotthus can take place. At higher temperatures the discrepancy between the ions of water and of other compounds vanishes; at 306° H˙ is only 1·6 times as fast as Cl′, as can be deduced from the tables (of Noyes, etc.) of mobilities up to 306°, and according to Kohlrausch the mobilities of various ions tend to converge to constant values at higher temperatures by varying their hydration. Considerations of the viscosity of water and of the diffusion of the H_2 molecule (after Nernst) support this argument. H. B.

1814. *Electrolytic Recovery of Zinc.* **S. Field.** (Faraday Soc., Trans. 17. pp. 400–431; Disc., 432–441, Feb., 1922.)—A discussion is given of the position of the zinc-smelting industry in this country and the relative advantages obtained by the electrolytic, electro-thermal and pyro-metallurgical methods for extracting this metal. Methods which have been applied for the calcining and leaching of ores and the purification of the zinc sulphate solutions prior to electrolysis are described in detail. The influence of various impurities during electrolysis is outlined, and the necessity for their thorough elimination emphasised. Oxidising agents, such as air, ozone, lead, and manganese peroxides have been employed for the removal of Fe, As, Sb, and Co. Zinc dust in a slightly acidified solution readily removes Cu, Cd, and Ni, greater speed of elimination, together with removal of Co, being obtained by the prior addition of about 0·005–0·01 % Hg as sulphate. The pure neutral solution is then acidified so as to contain 8 % Zn and 3 % H_2SO_4, and electrolysed between lead anodes and Al kathodes. The max. working temperature is 40–45° C., and the cells, arranged in cascade, absorb 3·35 volts and give a current efficiency of 90 %. This represents about 3200 kw.-hrs. per ton of zinc kathodes, which, after melting and casting, contain 99·95 % of zinc with not more than 0·02 % Pb, 0·02 % Cd, and 0·01 % Cu and Fe together. J. N. P.

1815. *Effect of Colloids on Overvoltage.* **N. Isgarischew** and **S. Berkmann.** (Zeits. Elektrochem. 28. pp. 47–50, Jan. 1, 1922.)—Anodic and kathodic overvoltages were measured by means of current–voltage curves during the electrolysis of $2N$-H_2SO_4 in presence of varying amounts of gelatine and gum arabic. Pt was used as anode, and Pt, Ag, and Au as kathode. In all cases with increasing concentration of colloid the overvoltage increased up to a max. value with from 1·5 to 2·0 % of colloid, and above this concentration the overvoltage fell. The position of the maximum was independent of the nature of the kathode, and is not determined by the viscosity of the solution. The results are attributed to the formation of absorption compounds between the colloid and the ions of the acid. At the maximum point the colloid becomes saturated with ions, while a higher concentration of colloid lowers the degree of dispersion of the medium and diminishes its absorption power. J. N. P.

1816. *The Measurement of Overvoltage.* **H. V. Tartar** and **H. E. Keyes.** (Am. Chem. Soc., J. 44. pp. 557–567, March, 1922.)—A comparison is made of the following two methods which have been applied for the measurement of overvoltage—(1) the commutator method in which the current is periodically interrupted with a rapidly rotating commutator; (2) the direct method in which the electrode potential is determined while the current is flowing. To obtain a potential of known value use was made of the fact that zinc may be deposited electrolytically from a strongly acid solution of its salts upon a kathode of metal of lower overvoltage by raising the current density until a transition point is reached, when zinc is deposited instead of hydrogen. In a solution containing H_2SO_4 and $ZnSO_4$, the e.m.f. given by the commutator method increased considerably with the speed of the rotation, but not with the c.d., until the transition point was reached, when zinc was deposited on the kathode accompanied by a sudden rise of the potential, the magnitude being determined by the composition of the electrolyte. At this stage, the p.d. was independent of the speed of rotation. The direct p.d. was found to increase gradually with increasing c.d., and showed no break at the point where zinc was deposited. The potential values obtained by the two methods of measurement thus become more and more divergent with increase of c.d. until, according to the direct method, the zinc potential is reached and this metal deposited. At this point the values obtained by the two methods approach each other closely. It is inferred from these observations that more consistent readings of the overvoltage are given by the direct than by the commutator method. The results indicate that the counter e.m.f. measured when the current is interrupted has not the same value as when the current is flowing. It is considered that the "transfer resistance" which has been assumed to account for the difference of the potentials as determined by the two methods, if it exists at all, cannot be of the magnitude which has been assumed.

J. N. P.

1817. *Electrolytic Estimation of Gold; Separation from Copper, Palladium, and Platinum.* **W. D. Treadwell.** (Helvetica Chim. Acta, IV. 3. pp. 364–374, 1921. Rev. de Mét. 18. E. pp. 605–607, Dec., 1921.)—Discussing the various electrolytic determinations of gold, the author considers potassium cyanide solutions preferable to others, but finds in joint experiments with G. Pfiffner, A. Guyer, and É. Jegge that solutions in hydrochloric acid to which ammonium acetate is added also give good results. Starting in the cold at 1 or 1·3 volt and heating to 60° in order to accelerate the deposition, this can be effected in 2 or 3 hours; stirring is also advisable. The kathode is platinum gauze, the anode a platinum spiral; the current density must not exceed 0·5 amp./dm.^{2} lest the anode be attacked. In this way gold may easily be separated from copper, and the quantitative analysis answers also for the gold-nickel alloys used as substitutes for platinum. In the separation of gold from palladium the potential must be kept below 1 volt; even at 0·7 volt the gold deposit may finally assume a grey tint, and it is best to keep the tension below 0·5 volt lest Pd be deposited. In the presence of platinum the electrolysis is started at 0·5 or 0·7 volt and finished at 1·5 volt. H. B.

1818. *Electrolytic Production of Sodium Perborate.* **P. C. Alsgaard.** (J. Phys. Chem. 26. pp. 137–155, Feb., 1922.)—A detailed summary is first given of the work done by Arndt (Zeits. Elektrochem. 22. p. 63, 1916) and Valeur (Tidskr. f. Kemi. Farmaci og Terapi, Kristiania, 1916, Nos. 17, 18), in which it was shown that the electrolytic preparation of sodium perborate is possible when carbonates are present in the solution; the carbonates probably form percarbonates during the electrolysis, and these then break down, giving the hydrogen peroxide necessary for the formation of perborates from the borates also present in the electrolyte. Large-scale experiments, on similar lines to those adopted by the above-mentioned authors, gave satisfactory results with 1·8 litres of electrolyte containing 45 gm. borax, 130 gm. Na_2CO_3, 45 gm. $NaHCO_3$, 2 gm. $K_2Cr_2O_7$, and 2 gm. waterglass. The temperature was kept at 10° C. by running cold water through a copper pipe used as kathode; the anode was of Pt, the current being 6 amps. with a current density of 25–35 amps./dm.^{2}. The object of the sodium bicarbonate is to absorb the CO_2 set free by the formation of perborate, and thus make up for the consumption of sodium carbonate. The current efficiency, with reference to the washed and dried salt, was about 40 %, the concentration of perborate in the solution when equilibrium between the rate of formation and decomposition was established, corresponding with 1·5 cm.^{3} *N*/10 $KMnO_4$ per cm.^{3} of electrolyte. Some figures are given to illustrate the cost of production on a scale of 1 ton of sodium perborate per day. T. S. P.

1819. *Electrolysis of Hot Concentrated Sulphuric Acid.* **H. Hoffmann.** (Zeits. Elektrochem. 27. pp. 442–445, Oct. 1, 1921.)—The electrolysis of sulphuric acid (98·3 % H_2SO_4) at a temperature of 50° C., and all current densities, gives, at the kathode, hydrogen sulphide and sulphur. At higher temperatures SO_2 and sulphur are given, and, in the neighbourhood of 300° C., SO_2 alone. At the anode oxygen is evolved, accompanied, at temperatures of about 200° C., by SO_2, which arises from sulphur diffusing from the kathode compartment and being oxidised by the nascent oxygen at the electrode. From 280° C. upwards, the SO_2 and oxygen are yielded quantitatively in accordance with Faraday's law. Potential measurements were made with a gas cell consisting of two Pt electrodes coated with platinum black and surrounded respectively with O_2 and SO_2 over an electrolyte of sulphuric acid. The experimentally found values of 0·123 volt at 97° and 0·032 volt at 227° C. were considerably below the calculated values derived from the Nernst thermodynamical formula. The low values obtained, which fall still lower on abstracting a small current, are attributed to the incomplete saturation of the Pt electrodes and the low reaction velocity of the gases. The decomposition voltage, measured by the rise in current curve with p.d. was again still higher and close to the value given for the decomposition voltage of water. It is inferred from this that the primary products in the electrolysis of sulphuric acid are H_2 and O_2, which then react secondarily to give SO_2. J. N. P.

1820. *Electrode Overvoltage in Relation to the Hydration of Ions.* **N. Isgarischew** and **S. Berkmann.** (Zeits. Elektrochem. 28. pp. 40–47, Jan. 1, 1922.)—In order to determine the influence on overvoltage of the physical properties of the electrolyte, measurements were made during electrolysis of the single p.d. between a small Pt plate and the surrounding electrolyte. A series of solutions containing in all cases the anion SO_4'' was used as electrolyte. Curves plotted to show the values of the current densities with gradually increasing p.d.'s gave a sharp rise at one point only, which is taken as the separation point of SO_4''. The rise in the curve through the separation of OH' is, on account of the small amount of these ions present, apparently masked by the effect of SO_4''. The separation potentials with solutions of normal concentration varied between the values 0·970 volt for $NiSO_4$ and 1·370 volt for H_2SO_4. No parallelism was found between the potentials and either the surface tension or degree of dissociation of the solution or the degree of hydration of the molecules as judged by the amount of water of crystallisation carried by the salts. A definite relation was found, however, between the separation potentials and the degree of hydration of the kations as calculated from a consideration of migration velocities. An increasing degree of hydration of the kation was accompanied by a diminishing separation potential of the anion. This is explained, in accordance with the influence of mass-action on equilibrium, by the theory that the larger the amount of water of hydration bound by the kation the less is available for the anions which leads to a lowering of the separation potential.

In the case of sodium sulphate the changes preceding electrolysis are given by the equations

$$(1)\ Na_2SO_4(H_2O)_r \rightleftarrows 2Na(H_2O)_{66} + SO_4''(H_2O)_n$$
$$(2)\ SO_4''(H_2O)_n \rightleftarrows SO_4'' + H_2O.$$

The general inference is in agreement with the experiments of Jones, which show by optical means that the introduction of $CaCl_2$ or other strongly hydrated salts lower the hydration of metallic salts.

By plotting the atomic weights of the kations against the separation points of the anions it is shown that a periodic relation exists between these two values giving a curve similar to the periodic relation between atomic volume and atomic weight. This is in accordance with the observation of Jones that ions of small atomic volume are more strongly hydrated than those of large atomic volume. An anomalous position is occupied by Al, which is related to the fact that the molecular hydration of aluminium sulphate is exceptionally large. J. N. P.

1821. *Influence of Chlorides on the Decomposition Voltage Curves of Chromic Acid.* **E. Liebreich.** (Zeits. Elektrochem. 27. pp. 452–455, Oct. 1, 1921.)—The periodic phenomena observed during the electrolysis of chromic acid are attributed to the formation of thin oxide or hydroxide layers which are of a colloidal nature, and in consequence of their positive charge are attracted by the negative charge of the kathode when the potential is applied. The rise in potential due to the increase in the resistance caused by the oxide film finally leads to its reduction to metallic chromium, when the cycle of changes is repeated. On the addition of chlorides to the solution during electrolysis, a displacement is obtained in the curves giving the relation between applied potential and c.d. This is attributed to the flocculating action of the salt in modifying the cohesion and porosity of the layer of colloidal oxide. [See Abs. 682 (1922).]

J. N. P.

1822. *Electro-Deposition of Lead from Mathers' Perchlorate Bath. I. Structure of the Deposit.* **W. E. Hughes.** (J. Phys. Chem. 26. pp. 316–323, April, 1922.)—The two-fold structure of the deposited lead is discussed.

L. H. W.